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CONTENTS

Refining Pennsylvania Lubricating Oils by Phenol Extraction ... 37
D. W. Kenny and W. B. McCluer

Regardless of Charging Stock Only Two Liquid Streams Recovered ... 41

Condensing Unit Conserves Makeup Water ... 44

Obtaining Accuracy in Orsat Analysis ... 46
John Griswold and J. W. Morris

Unit Costs for Compressed Air and Steam ... 50
J. R. Darnell

Topping and Cracking Get 58 Percent Recovery from Illinois Crude ... 53

The Refiner's Alloy ... 55
Weldon L. Archer

Process for the Conversion of Pennsylvania Bright Stock to Neutrals ... 60
C. R. Wagner

Elements of Vaporization and Condensation, Part X ... 62
R. L. Huntington

Equilibria in Reactions of Hydrocarbons ... 66
A. V. Frost

Acid Control of Scale in Cooling Waters ... 70

Expanding Business Bringing Expanding Markets ... 72
L. J. Logan

Liquefied Petroleum Gas in 1940 ... 80
G. G. Oberfell

Departments

Look Box ... 35 and 91

Plant Activities ... 107

Science and Technology ... 109

New Equipment ... 120

Business Notes ... 130

Catalogs and Bulletins ... 135

Advertisers' Index ... 136

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FLASH PROCESS NEWS

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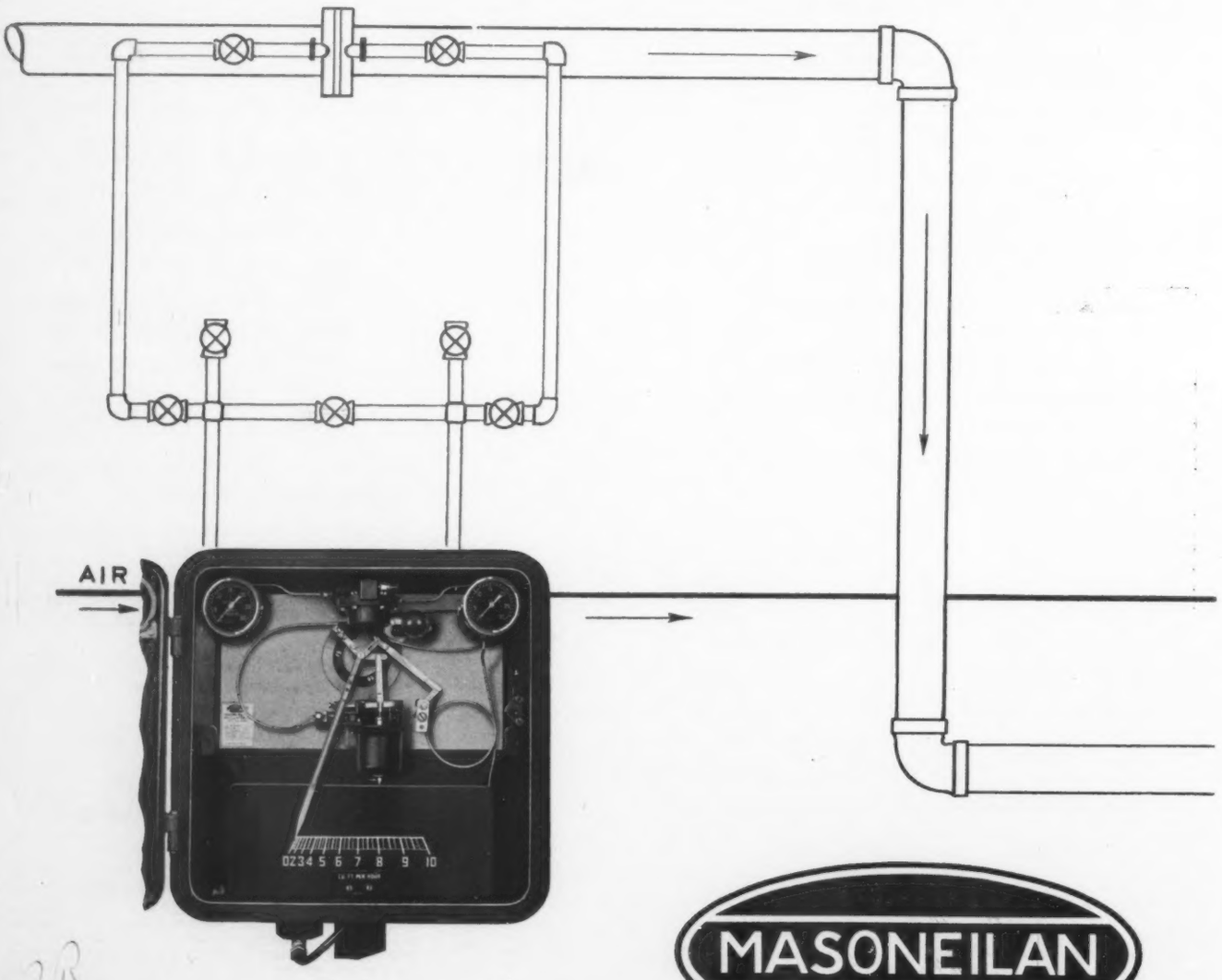

MASONEILAN

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VOLUME 20, No. 1 JANUARY, 1941

REFINER
AND NATURAL GASOLINE MANUFACTURER

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The Look Box

PERHAPS it would have been advantageous had the petroleum industry been compelled to provide its own market. Consumption of its foremost commodity, gasoline, has risen steadily for 35 years. More recently furnace distillate has risen in public favor. But the maker of gasoline has done little to assure this market.

Search For Markets

Consequently a growing market is taken for granted. The American people have bought and used more automobiles and higher gasoline consumption is a result rather than a cause. Through research gasoline has become better in quality; through improved equipment it has become more plentiful.

Thus, petroleum with an assured market is the envy of other industries. Men who grasp this conception seldom glance at the profit item in the oil balance sheet. In part narrow profit or no profit is the result of this assured market. Refining is an industry, wise in research and wise in manufacture but deficient in selling. Never has it been compelled to sit down before a stockpile of finished material for which there was no demand. This happened to the explosives industry at the close of the first World War and out of a problem came a new chemical industry.

Once more petroleum is moving into a market partly created. It is making toluol for explosives and synthetic rubber for industry. The call of war is the incentive. But war is temporary. Hence, petroleum may come to the end of fighting with plants and finished products and no demand. Then petroleum must adopt research for use to supplement research for production or it must become competitive with industries, which have created markets.

If petroleum supplants coal tar as a chemical source, it will come after an industrial struggle, something petroleum knows little about.

Some service to mankind, not now served, would give petroleum a safer market. That will require research for use along with research in the laboratory.

SINCE alloys are an essential to refining equipment, the industry should make certain that the required metals are listed with the priorities board of the National Defense Commission. Perhaps the word has been given. The necessity is so apparent, however, that caution is advisable.

Alloys Should Be Assured

Recently a study of alloy needs revealed that metals, especially chromium, molybdenum and nickel, are essential to the processes by which the industry must provide gasoline.

One of the associations, Western Petroleum Refiners Association or the National Petroleum Association, can give the matter attention.

IF some branch of the military should ask for bids on gasoline and get no response it would be the duty of the federal government to institute inquiry. Should inquiry reveal negligence, it would be the duty of the government to seek control of the petroleum industry, for this would be evidence of incompetence or lack of cooperation.

National Defense or Nationalization?

Since the defense program faces no lack of any petroleum product and has the full support of the industry, the proposal of the President that the Congress pass an oil-control measure is unfair and ill advised. It is ill advised because, thus far, agencies of government have not given the industry exact petroleum requirements. The industry is ahead of rather than behind government in national defense. It has a surplus of raw material, an excess of each gasoline the Army and Navy can use, and a plant capacity capable of making these in still larger quantities.

Control is asked for oil when the government faces nothing in oil that it does not face in steel or agriculture. The coming phalanx of tanks will stall for lack of rubber tires long before it stalls from empty gasoline tanks. In the United States there is no search for synthetic motor fuel and lubricants. Oil is one product this nation has in abundance.

Unless the government has needs, not yet passed to the industry, oil is not a part of the national emergency. When Dr. Robert E. Wilson spoke at the last annual meeting of the American Petroleum Institute he credited the industry with ample raw material, an over-built refining capacity and finished materials equal to current needs. He suggested normal plant expansion and preparation to make more 100-octane aviation gasoline within 18 months. His connection with the National Defense Council is such that his estimate is authority.

After analyzing this speech, the staff of Arthur D. Little, Inc., in its December, 1940 Industrial Bulletin, paid the petroleum industry this tribute:

"Far from being a bottleneck itself, the petroleum industry promises to relieve other bottlenecks. Two notable petroleum derivatives now becoming prominent are toluene, for TNT, and many types of synthetic rubber. Overlooking capital costs, toluene can be made from petroleum for less than current market prices. Synthetic rubber can be made in quantity at costs not greatly above the present crude-rubber price. Apparently the petroleum industry's genius for overbuilding, so often deprecated in the past, will prove a welcome boon as the defense program progresses."

Thus it could come about that oil would provide the war machine with tires and explosives as well as motor fuel and lubricants. It is ahead of the defense program and not behind it. This looks like leadership as well as cooperation. Why should government seek control on the plea of furthering national defense? Still national defense is part of the plea from the White House, as this paragraph shows:

"The vital need for petroleum in the national defense, its importance in commerce and industry and the critical conditions of Europe and Asia confirm my belief in the urgent need for federal legislation to safeguard our petroleum supply through the prevention of waste and by the establishment and maintenance of sound economic conditions in the oil industry."

Currently the industry is a step ahead on national defense. Along with that it is geared to supply the wants of commerce and industry and to fill the tanks of the several million automobiles that operate for business and pleasure. As for Europe and Asia, we import no oil from either. Exports to part of Asia are taboo and a score of refiners on the Gulf Coast would welcome opportunity to load a few tankers with gasoline, destined for the ports of a nation somewhere between Ireland and continental Europe.

Reference to waste is an inference that waste exists and that government can prevent it. Waste is evident only when instances of correction make it glaring. It is the industry which has overcome waste and thus made it possible for government to single it out. Of more significance, however, is the fact that the industry has contributed ten fold more to waste prevention than has government. The United States Bureau of Mines and all the state conservation commissions can show nothing to match cracking, catalytic refining, unitization at Van, repressuring at Tepetate or the program at Cotton Valley, to mention just a few.

Government bemoans waste. Industry corrects it. Synthetic rubber and toluene are out of the laboratory of the industry rather than the deliberations of government. Any progressive industry pulls a small load of waste.

An objective mentioned in the letter is "maintenance of sound economic conditions in the oil industry."

As free enterprise the industry has improved the quality of its merchandise steadily for 20 years and as steadily lowered its prices. Its wage scale ranks with the highest. As a vehicle for hauling tax money to public treasuries it has no equal. It has ample funds and is ready to invest in whatever additional plant capacity national defense and domestic consumption require. As a whole it earns profit out of which stockholders get dividends. It has asked for no public subsidy. [*Continued on page 91*]

Refining Pennsylvania Lubricating Oils By Phenol Extraction

D. W. KENNY, Research Engineer
and
W. B. McCLUER, Manufacturing Superintendent,
Kendall Refining Company

LUBRICATING oils of Pennsylvania origin have long occupied a favorable position in the industry, but retention of this status requires that Pennsylvania refiners carefully scrutinize new developments and adopt those best suited to their refining problems. Consistent with the policy of steadily improving the quality of its products, Kendall Refining Company, operating entirely on Bradford crude, made an extensive survey in 1935 and again in 1939 of the solvent extraction processes which were commercially available. Included in this research program was the construction of a small-scale extraction pilot plant which was operated on several different stocks under a variety of different conditions. Block and fleet engine tests were run on solvent-treated oils produced at the pilot plant and a critical examination of all the factors involved led to the installation of a commercial phenol extraction plant. Selection of this process was based on a detailed consideration of investment costs, operating costs, quality improvement, ease and flexibility of operation and adaptability of the process to present and future refining requirements.

No information relating to the commercial extraction of Pennsylvania oils with phenol has previously appeared in the literature and it is therefore the purpose of this article to describe this plant and to discuss its operation.

Aromatic and naphthenic compounds, which are undesirable as lubricant components, are relatively soluble in a selective solvent whereas the valued paraffinic compounds are relatively insoluble. Extraction of an oil through contacting with such a solvent results in a quality improvement dependent upon the selectivity of the solvent under the treating conditions used and the quantity of extract removed. From the commercial standpoint, the efficiency of the process and the yield of raffinate are of paramount importance especially when operating on expensive Pennsylvania stocks.

The solvent, in addition to its selective properties, should be economically available, chemically stable under conditions of storage and use, and capable of full recovery. Phenol satisfies all these requirements and in addition its use does not require expensive corrosion-resistant materials of construction.

The plant was designed to handle 1500 barrels of oil and 1400 barrels of phenol per stream day. The actual operating capacity of the plant depends therefore on the type of stock handled, the solvent dosage, the selectivity of treat, and the amount of extract removed. On the basis of 10 percent extract removal, the nominal design capacity was 1250 barrels for dewaxed neutrals, 1050 barrels for 150 viscosity residual stock, and 500 barrels for residual stock having a viscosity of 2000 Saybolt Universal seconds at 210° F.

The commercial plant, designed and constructed by The M. W. Kellogg Company, met its guarantees during a 10-day run on residual stocks in February, 1940, and subsequent operation on widely different stocks has been entirely satisfactory.

A simplified flow diagram is shown in Figure 1. The charge stock is pumped from storage through a low-pressure steam heater to the absorber where phenol contained in excess phenolic water vapor from the recovery system is absorbed by the incoming charge. The absorber temperature is maintained at about 235° F. in order to prevent condensation of steam and the reintroduction of undesired water into the system. The oil, containing a small amount of phenol, is pumped from the base of the absorber under flow control through a cooler to the treating tower where continuous countercurrent extraction with phenol is effected. The exact feed location for the oil depends upon the stock being treated but in any case the oil enters as the discontinuous phase and rises through the extract-phenol solution in droplet form. An interphase level is maintained at approximately 70 percent of the tower height and above this point the oil forms the continuous phase with the down-flowing phenol existing in droplet form. The treating tower contains 19 packed trays which serve to collect and redisperse the discontinuous phase, thus improving distribution and contacting efficiency. Anhydrous phenol (or if desired, phenol containing a small but controlled amount of water) enters the top of the treating tower and phenolic water (containing about 11 percent phenol) is introduced in controlled amount at the base. The purpose of the phenolic water is to provide reflux in the treating tower.

Treating Tower

Operating conditions for the treating tower depend upon the stock being treated. When extracting distillate stocks, the tower-top temperature is maintained at 150-155° F. and the tower-bottom temperature is maintained at 110° F., the solvent dosage amounting to 60-65 percent of the oil charge. When extracting residual stocks, the tower-top temperature is maintained at 225-230° F. and the tower-bottom temperature is maintained at 155° F., the solvent dosage amounting to 130-140 percent of the oil

charge. Tower-top temperatures are maintained by controlling the temperature of the entering phenol and tower-bottom temperatures are maintained by controlling the temperature of the charging stock at the absorber after-cooler. In general, the entering phenol temperature is maintained 15 to 20° F. below the miscibility temperature of phenol and oil and the tower-bottom temperature is controlled as low as possible without encountering treating difficulties as a result of the increase in oil viscosity at low temperatures. Solvent dosage is determined almost entirely by tower-bottom temperature, the amount of phenolic water added to secure reflux, and the amount of extract to be removed.

The raffinate solution, containing about 20 percent phenol, overflows the top of the treating tower into an accumulator from which it is pumped through a heat exchanger to the raffinate side of the furnace, emerging from the latter at a temperature of 550° F. At this temperature the phenol content of the raffinate solution is reduced to approximately 4 percent through vaporization of the phenol. The solution-vapor mixture flows to the evaporator section of the raffinate tower where the vapors, containing more than 99 percent phenol (the remainder being water) are flashed over into the drier section of the phenol tower for subsequent recovery. The lean raffinate solution flows to the stripping section of the raffinate tower where the remaining phenol is removed by steam-stripping under a vacuum of about 22 inches of mercury. The steam-phenol vapors are condensed and pumped to the extract solution accumlator for subsequent separation of the phenol and water. When treating light distillates, the stripper temperature necessary for complete removal of phenol from the raffinate sometimes results in the inclusion of a small amount of oil in the stripper condensate and in this event the condensate is returned to the raffinate solution accumulator. Stripped raffinate, containing not more than 0.001 percent phenol, is pumped through heat exchangers and a cooler to finished oil storage.

Stripping Economics

It should be indicated at this point that the degree of stripping required is, within reasonable limits, a function of economics alone since laboratory tests show that clay treating raffinates to a yield of 50 barrels per ton will reduce the phenol content from 0.1 percent to 0.001 percent and from 0.01 percent to an indeterminable amount. As indicated above, however, no difficulty is encountered in holding the phenol content of raffinates down to 0.001 percent as they are produced at the extraction plant.

The extract solution flows from the base of the treating tower to the extract solution accumulator, the flow being regulated by an interphase level controller in the treating tower. From the accumulator, the solution containing about 85 percent of phenol, 8 percent of water, and 7 percent of extract is pumped to the recovery system. This system comprises a multi-sectioned phenol tower, exchangers, a furnace, and an atmospheric stripping tower. The extract solution enters the drying section of the phenol tower where all of the water is removed in the form fo a constant-boiling mixture containing approximately 11 percent phenol and 89 percent water. (Phenol vapors from the evaporator section of the raffinate tower also enter the drier as previously described). Phenol cannot be recovered from this constant-boiling mixture by ordinary distillation methods and consequently the production of phenolic water in quantities greater than that required in the

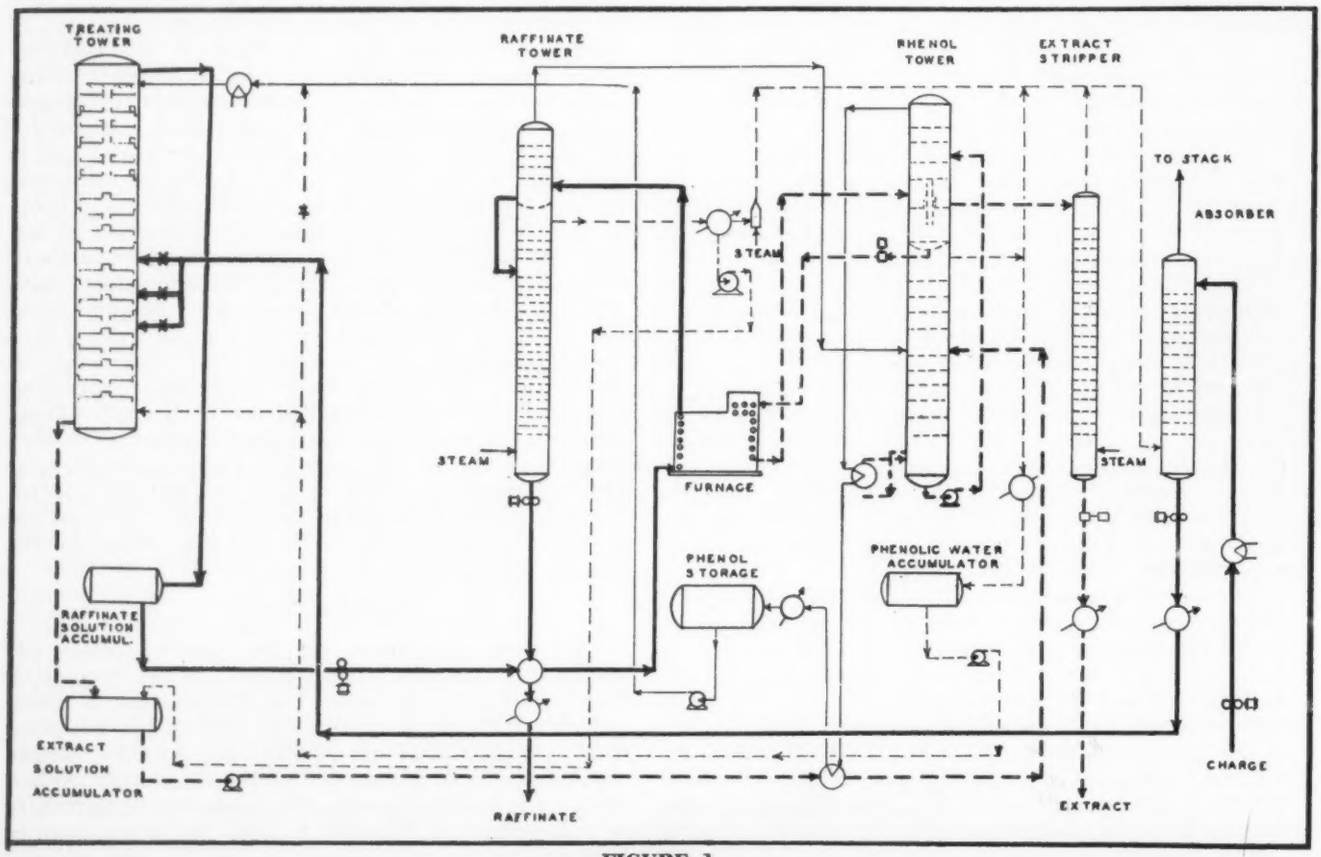
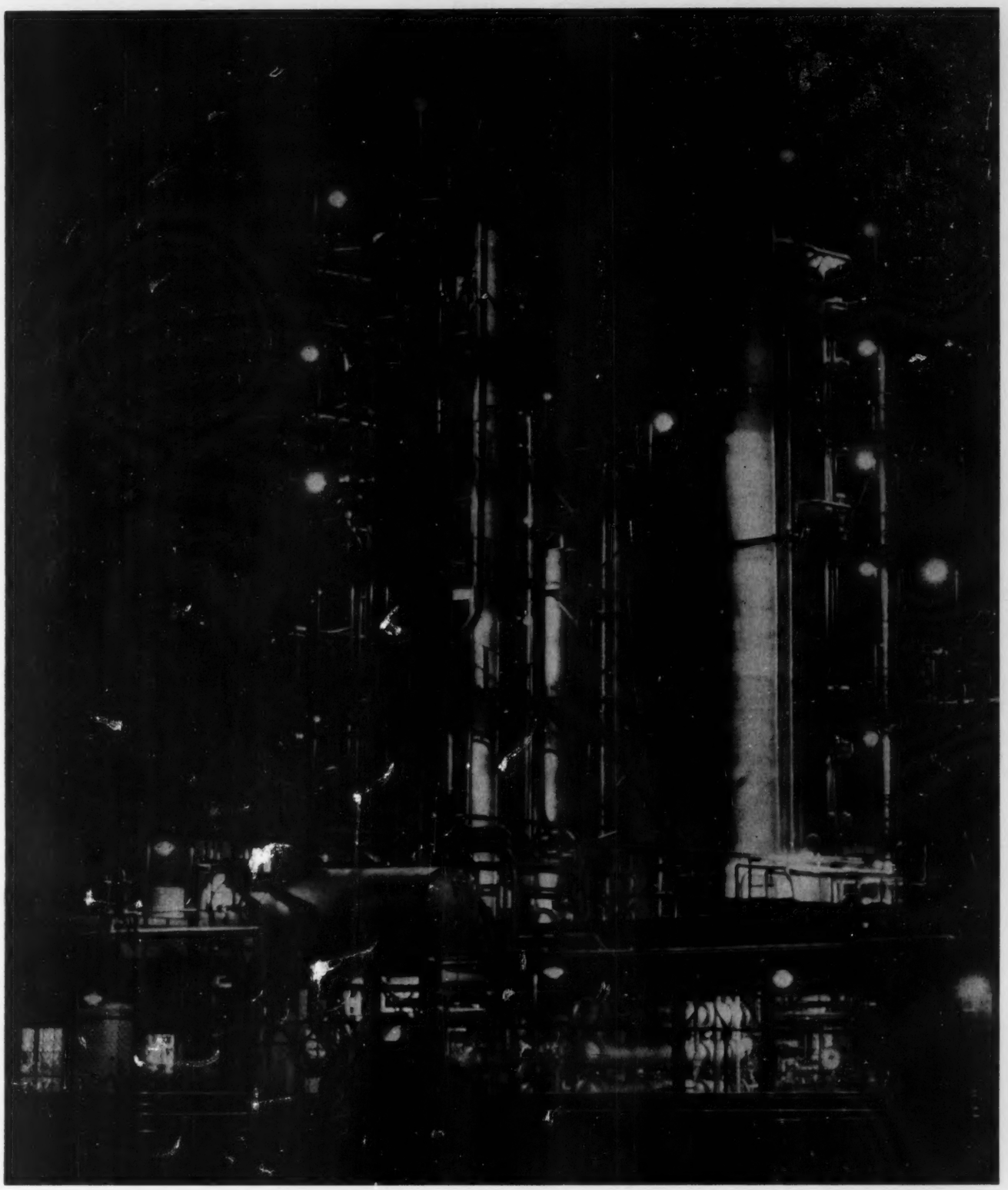


FIGURE 1
Flow sheet of commercial plant



Phenol Extraction Unit

treating tower plus the quantity which can be handled efficiently by the absorber is to be avoided since any excess over this amount represents an inventory of undesired phenolic water. The only water voluntarily introduced into the system enters as stripping steam and consequently the plant is designed to remove this quantity in the absorber vent gases.

The phenolic water condenser is mounted vertically near the top of the drier section of the phenol tower and the pressure in the drier is controlled at 5 to 10 pounds gauge by maintaining a definite condensate level in the condenser. A portion of the phenolic water vapors, corresponding to the quantity of raffinate stripping steam used, flows directly from the drier to the absorber. By increasing the pressure on the drier as described above a larger quantity vapors is diverted to the absorber (and less to the

condenser) and provision is thereby made for disposing of occasional excess amounts of phenolic water. The condensed phenolic water flows to the phenolic-water accumulator to serve as recycle to the treating tower and as reflux for the drier section of the phenol tower.

The dry extract solution is pumped from the base of the drier section to the evaporator section of the phenol tower. In this section of the tower, which is maintained at a pressure of approximately 25 pounds gauge, a portion of the phenol in the extract solution is vaporized, through contact with hot vapors returning from the furnace. The remainder of the extract solution drops to an accumulator section in the tower from which it is pumped through the convection section to the extract side of the furnace. Leaving the furnace at about 650° F. the hot extract solution flows back to a mid-point in the evaporator section where the hot phenol vapors are released. The lean extract solution then flows to an atmospheric stripping tower where the phenol content is reduced by steam stripping to about 0.005 percent.

It should be noted that all the heat required for removing water from the extract solution is obtained by condensing phenol vapors from the evaporating section of the phenol tower. In this sense, the phenol tower is constructed on the multiple-flash principle.

The anhydrous phenol vapors from the evaporator section of the phenol tower pass through the drier reboiler, heat exchangers, and a cooler into the phenol storage drum for recycling through the treating tower. The steam-phenol vapors from the extract stripper flow directly to the absorber for recovery of phenol. Vent gases from the absorber, containing about 0.1-0.5 percent phenol and 99.9-99.5 percent water plus noncondensibles, are discharged to the furnace stack. Operating experience has indicated that the plant is capable of disposing of somewhat greater quantities of phenolic water than are normally produced through the use of stripping steam and therefore the accidental accumulation of small amounts of excess phenolic water is easily nullified by rerunning this excess through the drier and absorber. Data for several months' operation indicate that phenol recovery amounts to 99.96 to 99.97 percent of the phenol circulated.

Instruments and Control Devices

The plant is well equipped with instruments and control devices. Operation is simple and flexible to the extent that only two men per shift are required for the entire operation of the plant. Specifications on products are easily maintained and rerunning is necessary only for slop produced during changeovers to other stocks. The normal melting point of anhydrous phenol is 105.6° F. Consequently all lines carrying phenol or phenolic water are steam-traced to prevent freezing and plugging of the lines, and no difficulty of this nature has been experienced. The plant is well equipped with safety devices and in 10 months' operation no lost time accidents of any nature have occurred.

Shut downs due to equipment failure have been at a minimum; corrosion has occurred only to a minor degree and is not considered serious. All utility requirements are within the guarantees of the contractor and operation to date on all stocks has been entirely satisfactory.

Even though it is generally recognized that inspection data on oils are not always indicative of oil quality and that all oils must be tested in full-scale automotive equipment before quality can be established, certain inspection data are given in Table 1 which are representative of the improvements effected by treating with phenol.

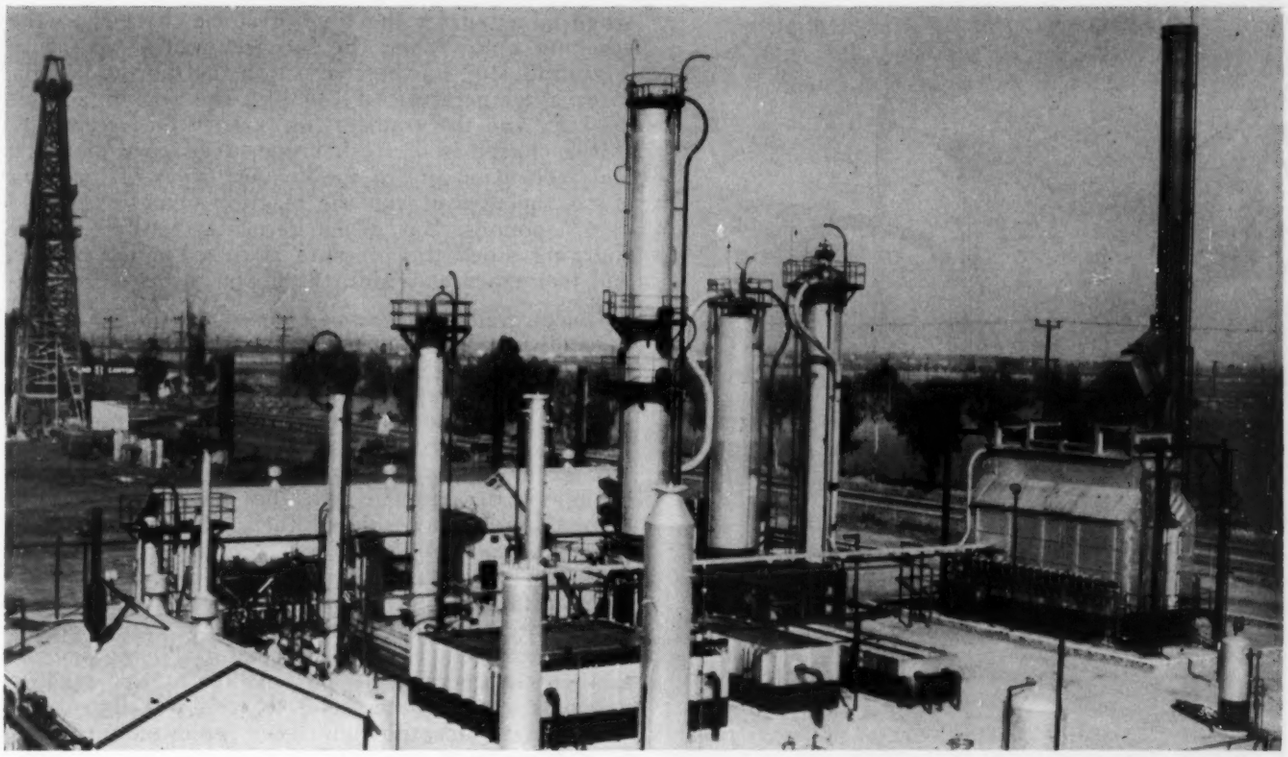
Dewaxed 180 and 350 neutrals which have been phenol treated show a substantial increase in viscosity index, an increase in gravity, a slight reduction in viscosity at 100° F., and no change in volatility as reflected by flash and fire tests. Filter yields on these stocks for a given color have been increased materially and the Indiana Oxidation stability has been improved greatly. The carbon residue on these stocks is very low initially and any improvement in this test is of no consequence. It is interesting to note, however, that the carbon residue of the extracts are relatively high, the viscosities are very high and the flash and fire tests are relatively low. These facts are pointed out only because of the bearing which they have on the mechanism of solvent extraction.

Inspection data covering 120-viscosity bright stock are similar in all essential characteristics to those previously discussed for neutrals and in addition it is evidenced that the carbon residue of bright stocks is reduced substantially by phenol treating without loss of volatility as evidenced by flash and fire tests. It is also interesting to note the very high visocsity, the low gravity, the low flash and fire points, and the high carbon residue of the extract. Filter yields for this stock to a given color have been greatly improved as has also oxidation stability as evidenced by viscosity change during oxidation and by Navy Work Factor ratings.

Inspection data for one very high viscosity stock are also given. The purpose in presenting these latter data is to show the extreme flexibility of the plant, and the improvement in gravity and carbon residue which can be effected in stocks having a viscosity in the neighborhood of 800 Saybolt Universal seconds at 210° F. The viscosity, gravity, and carbon residue of the extract from this stock are of considerable interest.

TABLE 1

	DEWAXED MOTOR NEUTRAL				DEWAXED HEAVY NEUTRAL				DEWAXED, DERESINED 120 VISCOSITY BRIGHT STOCK				"600" VISCOSITY RESIDUAL STOCK		
	Charge	Extract	Raff.	Filtered Raff.	Charge	Extract	Raff.	Filtered Raff.	Charge	Extract	Raff.	Filtered Raff.	Charge	Extract	Raffinate
Gravity, °A.P.I.	30.1	12.0	.....	.....	28.6	10.2	.....	.....	25.8	9.9	27.8	27.9	20.6	8.7	24.0
Flash, ° F.	425	420	425	420	465	445	465	460	550	525	550	550	620	585	620
Fire, ° F.	475	475	475	475	525	515	525	520	620	.....	620	615	700	.....	700
Viscosity at 100° F.	173.5	1130	162.0	161.5	409.6	17,490	322.0	317.6	2114	.....	1625	1615	41,855	.....	20,815
Viscosity at 210° F.	43.8	60.4	.....	.....	57.5	161.6	.....	.....	135.0	830	120.5	120.1	840.5	5,950	629.5
Viscosity Index	97.0	—99	.....	.....	94.8	—240.6	.....	.....	96.2	.....	101.7	101.8	92.9	.....	102.1
Pour Point	0	.....	0	0	0	.....	0	0	0	.....	0	0	25	.....	20
N. P. A. Color	4½	Black	3½	2—	7½	Black	5+	3—	8	Black	7½	5	.....	Black	.....
T. R. Color	8⅝	.....	9⅛	16	.....	.....	.....	9⅝	1⅜	.....	.....	4½	.....	.....	.....
Conradson Carbon	.....	0.23	.....	.....	.....	1.6	.....	.....	1.52	.....	0.80	0.75	6.0	18.4	3.3
Yield—percent	100	.....	.....	.....	100	.....	.....	.....	100	10	90	.....	100	15	85



Plant of the Fletcher Oil Company, Wilmington, California

Regardless of Charging Stock, Only Two Liquid Products Recovered

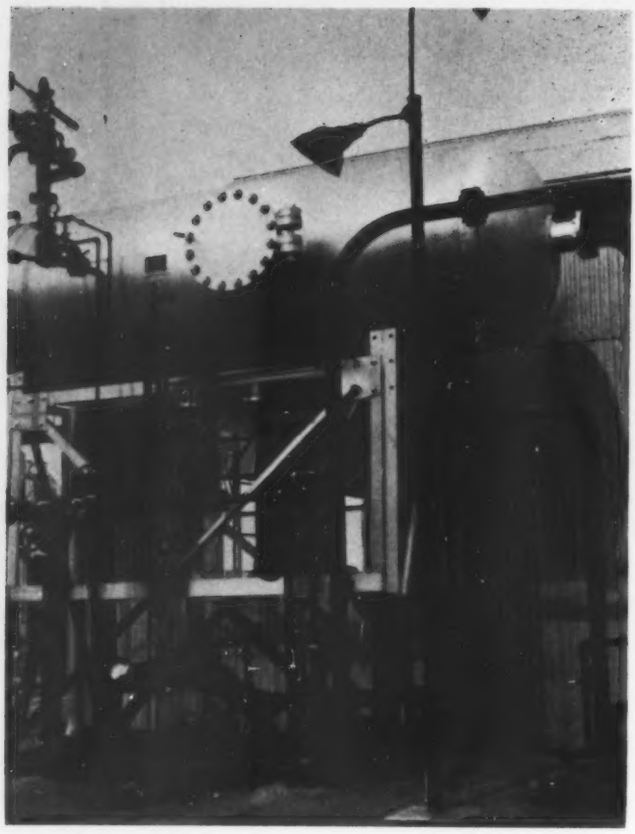
ALTHOUGH designed to operate on gas oil charging stock, the cracking plant of Fletcher Oil Company at Wilmington, California, processes any type of charging stock with only two products recovered as liquids; cracked gasoline and a low-gravity, low-cold test, high Btu industrial fuel oil. As a by-product, catalytic polymer gasoline with a high blending value is recovered by converting the unsaturates in the overhead vapors from the cracked gasoline stabilizer. This is immediately pumped back into the cracking plant at the inlet of the flash chamber, so that the heavy ends may be separated while the desired boiling range fractions are blended with the cracked product and condensed along with the pressure distillate.

The charge to this cracking plant varies from day to day, and frequently the type of the charging stock is changed twice daily. If fresh crude is in the storage tanks, that may be cracked alone or blended with a heavy topped crude obtained from other refineries. Again, the material on hand may consist of slops, topped crude, heavy fuel and crude oil, all of which after blending, or as is, may be charged directly to the main column in the usual manner. It appears to matter little what stock is available, as the plant operating conditions can be changed without loss of stream time or a reduction in throughput. And the plant continues to produce two products without any appreciable change in the quality of either.

Reaction Chamber Different

One of the units in this plant that is different from most cracking plants is the reaction chamber. Instead of being designed to operate at the conventional pressure of 275 pounds, this chamber is designed for an operating pressure of 600 pounds if required, and it is frequently run at a pressure as high as 550 pounds, particularly when the charging stock consists of kerosine distillate. The chamber is 4 feet, 6 inches in diameter and 40 feet high, with 1-7/16-inch walls, fusion welded and stress relieved, and lined throughout with an 11-16 chrome steel sheel.

The charge is picked up from plant storage with a 7½ x 5 x 10-inch duplex, steam driven, plunger pump equipped with automatic pressure and steam controllers, and delivered through a shell-and-tube residuum-to-charge heat exchanger by a 2-inch charging line to the main fractionating column where it is introduced by a nozzle placed at the top of the first side-to-side stripping tray. The fractionator is



Pressure distillate receiver with liquid level control

5 feet 6 inches across and 55 feet high, made with ½-inch walls and lined with an inner shell of 11-13 chrome steel, 5/32-inch thick from the vapor outlet to the top of the last bubble plate. There are 16 bubble plates, made of cast iron, occupying the upper portion of the tower above the 8 side-to-side stripping trays. Each bubble deck is connected to the one below with multiple down pipes, consisting of groups of four 6⅜-inch tubes placed so that the stream of reflux and condensate will be forced to pass from side to side. Two draw-off nozzles are supplied to this column, one at the twelfth bubble tray to supply reboiler heating and absorption oil. The other is placed at the eleventh plate but blanked off for use if and when the plant is converted to two-coil operation to supply the stream of light oil cracking stock.

An outside plunger packed, 5⅝ x 16-inch steam-engine-driven hot-oil pump takes suction at the bottom outlet of the main column for the cracking charge, and delivers this material through a 4-inch line to the up-shot combination gas- and fuel oil-fired heater. The flow through the heater begins at the top row of convection tubes and flows downward through 48, 4-inch O.D., 3½-inch I.D. tubes, 28 feet long. This bank is followed by another containing 8, 3¾-inch O.D., 3-inch I.D. and two other banks, one on each side of the furnace walls, each containing 26 tubes, 3¾-inch O.D., 3-inch I.D., 28 feet long ending in the transfer line.

The gas burners are placed against the bridge wall, a full complement on each side, and the fuel-oil burners are placed in the outer walls.

The temperature at the thermocouple reference points within the heater remain constant at the point when adjusted for the type of stock charged to the cracking unit. When the furnace inlet temperature is around 640° F., the convection thermocouple indicates a temperature of 740° F., the soaking outlet 860° F., and the transfer, or furnace outlet 930° F. If the charge is of fresh crude, a mixture of crude and fuel oil or any of the heavier types of cracking stock, the pressure on the reaction chamber is held at 275 pounds. But, when kerosine distillate is the charging stock the pressure is raised much higher, and temperatures within the heater adjusted accordingly.

Recycle Ratios

Flash chamber pressures are always sufficiently high to drive the residuum from the column outlet through the exchanger and product coolers and to storage without pumping. Vapors from the flash chamber are conducted to the main column inlet through an 8-inch insulated line for fractionation into high-octane gasoline and recycle stock. The ratio of recycle is about 4.45 when kerosine distillate is charged to the unit, resulting in a cracking efficiency of about 15.2 percent per pass, and the ratio is about 3.4 when crude is charged, this material being cracked at about 13.5 percent per pass. When the recycle rate averages approximately 6300 barrels per day of hot oil to the furnace, the quantity of reflux pumped back to the overhead control point of the fractionating column is about 2200 barrels per day, resulting in a reflux to recycle ratio of about 1:2.9. When the top of the column is held at 372° F. to manufacture a 400-end-point cracked gasoline, the reflux ratio is about 2.2:1, reflux to cracked gasoline production.

Vapors from the column are conveyed through an 8-inch line from the top of the column to the submerged condensers which have a total cooling surface of 4628 square feet. The condensing temperature is held at about 85° F. with the condensate and vapors passing to the distillate receiver for separation. Vapors which are not condensed flow to the 16-tray absorber—which is 2 feet 6 inches I.D. and 22 feet 6 inches high—where they are contacted with a cut removed from the twelfth tray in the main plant fractionating column. This product has a gravity of 37.5° A.P.I., and an initial boiling point of 180° F., and an end point of 470° F. It is cooled with 50 lengths of 3-inch pipe placed in a condenser box through which water is pumped from the aerator type cooling tower. Part of this absorption oil cut flows through the fractionator reboiler before entering the absorption oil cooler, and the rich oil—or absorption bottoms—is pumped with a 6 x 4 x 6-inch steam pump to points within the cracking system requiring cold oil for temperature control. If the plant is being operated with kerosine distillate as the cracking charge, part of this rich oil is pumped with a 7½ x 3½ x 10-inch duplex pump to quench the inlet of the reaction chamber, but is not necessary when crude or fuel oil is the charging stock.

Raw cracked gasoline is pumped from the receiver by a 7½ x 4 x 10-inch steam pump to the stabilizer for vapor pressure control, to remove excess butane and to produce unsaturates for the polymerization plant by extracting the olefins from the raw feed. This stabilizer is 3 feet in diameter and 38 feet 6 inches high, containing 26 cast iron bubble trays, with the feed entering above the fifteenth plate. When the column is operated at a pressure of 193 pounds, the reflux to feed ratio is about 2:1. The

stabilized material passes out of the reboiler through feed-to-product exchangers and to storage. The vapors from the pressure distillate pass at column pressure to the polymerization plant where a steam heater is placed in the line ahead of the gas-engine-driven compressor. The gas is boosted from intake pressure to 500 pounds and passed through a vertical heater containing a pipe helix through which the gas passes while being raised in temperature.

Polymerization Plant

The two catalytic columns are of the non-selective hook-up, passing through the beds of carrier impregnated with phosphoric acid. The catalytic column are made with ¾-inch walls and are 24 inches in diameter with a height of 14 feet 6 inches overall. Flanged heads at the top and the bottom facilitate removal of spent catalyst and refilling with fresh material. Water control, or rather the moisture content of the catalyst bed is necessary for reaction, and this is fed to the towers and stream of gas with a small proportioning pump.

The condensate from the polymerization plant is passed to the stabilizer to remove low-boiling fractions not changed in characteristics while the liquid is passed back to the cracking plant flash chamber inlet to re-run for the removal of the small quantities of high-boiling fractions. The polymer stabilizer is 18 inches I.D. and 30 feet 6 inches high, filled from supporting plate to the top with ½-inch ceramic Rachig rings, instead of the conventional bubble plates used in other columns. The quantity of poly gasoline varies with the type of charging stock, running as high as 2.9 percent of the feed from kerosine distillate, and as high as 1.5 percent when crude or heavy residuum is the charging stock. By following the type operation at this plate, the finished pressure distillate is the only product recovered, and is employed as a basic material for motor fuel.

The yields of products when operating on a typical charge of 2350 barrels of 32.5-gravity crude is as follows:

	Percent
Pressure distillate	67.25
Poly gasoline	1.50
Residuum	27.25
Gas and loss	4.00

And when the charge consists of 1275 barrels of kerosine distillate, the yields are:

	Percent
Pressure distillate	73.2
Poly gasoline	2.9
Residuum	13.9
Gas and loss	10.0

The residuum resulting from each type of charge is shown below.

Gravity	Resid. from Heavy oil 7.5° A.P.I.	Resid. from K.D. 1.0° A.P.I.
Viscosity	135	30
Flash	170	180
Pour	35°F.	0°F.

Products resulting from cracking are as follows:

	Crude P.D.	K.D. Pres. D.	Poly stream
Gravity, A.P.I.	57.2	57.1	63.8
IBP, °F.	84	81	70
10 percent	142	142	130
50 percent	263	276	232
90 percent	365	384	
E.P.	395	402	424
Recovery, percent	97.5	98.0	90
R.V.P., pounds	8.5	8.5	15
Octane	68.5	72.8	

Reboiler and exchanger on the pressure distillate stabilizer

Condensing Unit Conserves Makeup Water

BECAUSE of the necessity and expense of treating boiler water in the K-M-A field, Continental Oil Company has installed a condensing unit which converts exhaust steam into water for reintroduction into the boiler-feed stream. The unit consists of a 10-section tubular radiator, two turbine-driven fans, an accumulator, liquid-level control and steam-driven pump for delivering recovered water back to the boilers.

Location is at one end of the main water-cooling tower to assure free air circulation. The fans are on the south side of the radiator, as prevailing winds are from this direction.

The radiator consists of 10 removable sections, all held within an I-beam frame, which is mounded on concrete piers. The vertical tubes are surrounded with copper fins to increase exchange efficiency. Each section has individual intake at the top with gate valve control, so a section may be cut out of service without interfering with operation of remaining sections.

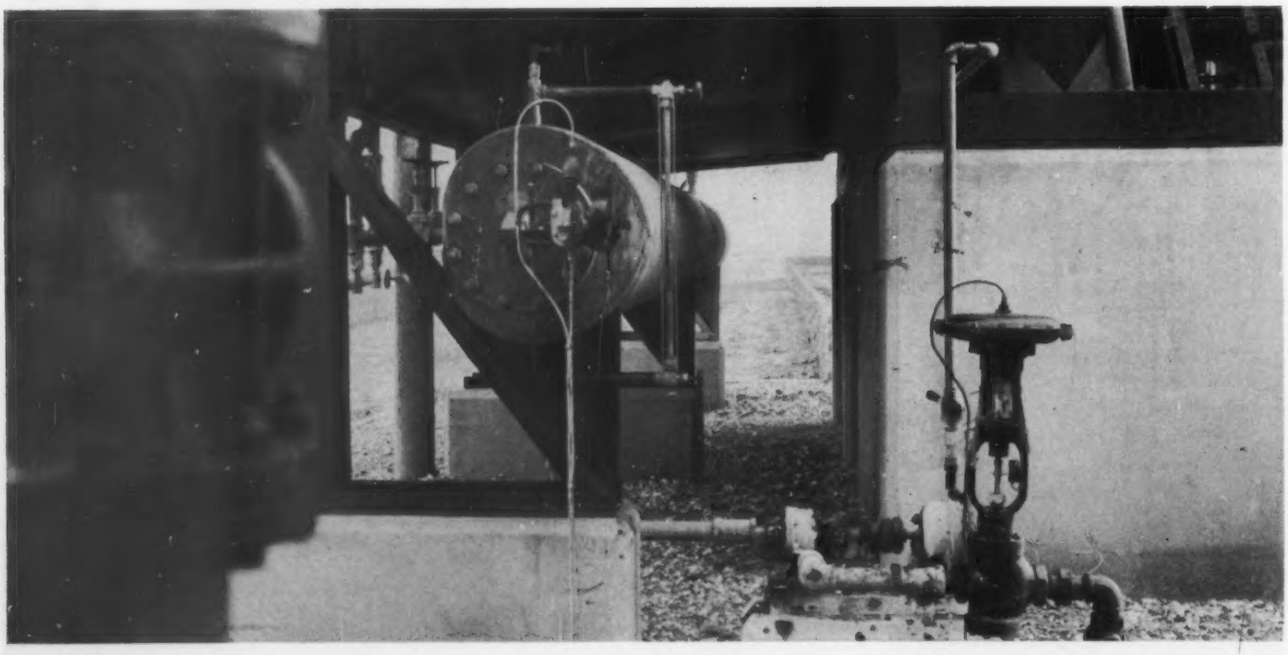
Constant air volume is provided by two V-belt-driven circulating fans, each set in a shroud. The fans are driven by a 90-horsepower steam turbine, which is anchored to a separate concrete pier. The turbine shaft is connected to a speed reducing unit, from which each fan is driven by pulleys and V belts.

Steam for the turbine is delivered to the intake controllers through an insulated line, carried on stanchions. Exhaust from the turbine leads downward and connects to the exhaust steam for delivery to the radiator intake header.

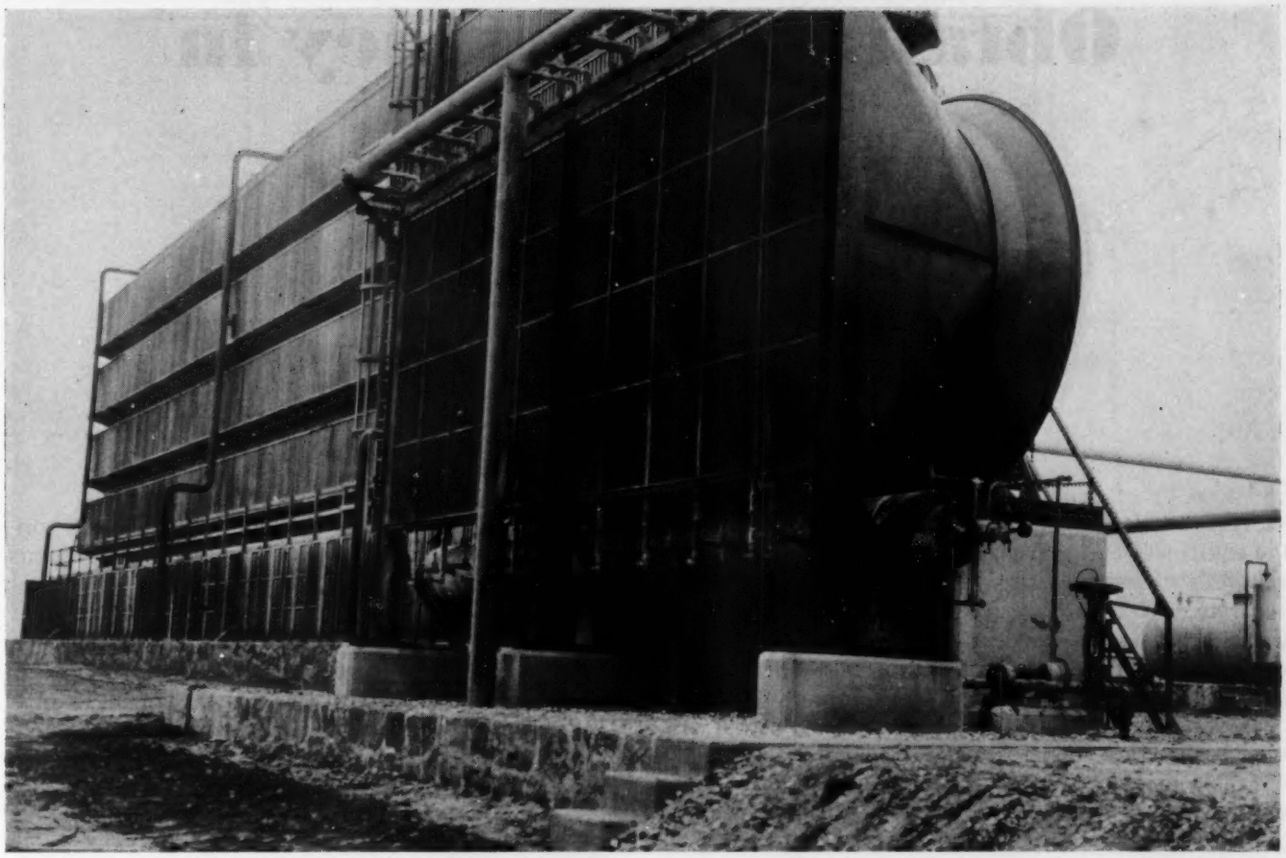
The unit draws exhaust steam for several turbines as well as the compliment of reciprocating pumps. A header originates in the main pump room, where all transfer and control units are located, and leads outside the building to pass through a riser, which is connected to an underground pipe, which in turn rises at the radiator unit and terminates in a horizontal distribution header which has a connection to the top of each tubular radiator section.

Beneath the radiator is a horizontal accumulator drum, resting on steel cradles which are mounted on concrete piers. The drum is connected to the bottom of each radiator section through pipe and gate valve control. One end of the accumulator is equipped with liquid-level control, which is remotely connected to an outlet control valve, which permits recovered water to flow constantly to a small turbine-driven centrifugal pump, which delivers to the makeup tank.

The unit is designed to condense 8,000 pounds of exhaust steam per hour with a fin surface of the radiators at 114° F. Operation is automatic. Other than regular inspection and lubrication it requires little attention.



Liquid level control at one end of the accumulator feeds recovered water to a steam turbine driven centrifugal pump, for return to boiler makeup tank.



Feed for the unit is through a riser and horizontal header. Note the individual inlet for each radiator section at the top. Below the pipe and valve connection between each section an accumulator is shown. This arrangement permits cutting one or more radiator sections out of service.

Fan power is from a steam driven turbine. Its exhaust connects to the combined plant exhaust for condensation and water conservation. Stairs and walkway are for inspection and lubrication. Fan power is through a speed reducing unit, pulley and V belts.

Obtaining Accuracy in Orsat Analyses

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THIS article presents essential details for the use of the equipment and preparation of reagents for the conventional Orsat apparatus, by which flue gas analyses accurate to 0.1 percent may be consistently obtained. Certain precautions frequently overlooked may result in errors of several times this figure. More often than otherwise, an Orsat apparatus is not in daily use. For this type of service, dependable, easily prepared reagents which are stable over a period of time are more desirable than others giving faster analyses but which must be made up fresh daily and may require special techniques. A selection of reagents has been made with this in mind.

An instrument of the common style and size was used throughout this investigation. The measuring burette was of 100 c.c. capacity. The absorption pipettes packed with glass tubing were charged with 150 c.c. of reagent. The special precautions found necessary for accurate determinations with this type of apparatus are:

1. The measuring burette should be frequently checked for drainage error, and be cleaned whenever necessary with acid-dichromate solution.

2. The burette, its capillary connection, and the manifold tubing should be calibrated and the total volume of the sample taken for analysis should be corrected accordingly.

3. Whenever a volume measurement is to be made, the gas should be drawn into the burette slowly during a period of 30 seconds and followed by a 30-second wait for complete drainage.

4. The potassium pyrogallate reagent for oxygen absorption is dependable only when made up with *saturated* KOH solution.

5. The fact that acid cuprous chloride solution is very slow in rate of absorption must be allowed for, and it should be renewed after absorption of 8 to 10 c.c. of CO. It this gives quantitative absorption without liberating HCl or CO.

Barometric Pressure.

A difference of three fourths of a millimeter in barometric pressure affects the observed gas volume by 0.1 percent. Barometric fluctuation during an analysis is usually less than this, but in changeable weather atmospheric pressure may increase or decrease by as much as 5 millimeters in less than an hour. Therefore the barometer should be read at the beginning and conclusion of an analysis so that when need be, corrections may be applied to the CO_2, O_2, and CO figures proportionately to the time spent for the determination of each. Carbon monoxide when present requires the most analytical time by the procedure recommended in this article, and is also the most sensitive to pressure variation when only small amounts are present.

Sampling and Measuring

Burette Drainage.

When an aqueous confining liquid, the time for water film drainage down the sides of the gas burette is the same as that encountered in volumetric analysis when liquid is measured. Thirty seconds were sufficient to drain the burette to a residual film volume of less than 0.05 c.c. only when it was freshly cleaned with acid-dichromate solution. After several gas samples had been tested, the liquid film became noticeably greater in volume and required a longer draining period.

A dependable procedure is to *withdraw the confining liquid slowly over a period of 30 seconds,* then allow an additional 30-second wait. This resulted in complete drainage whenever the burette was clean enough to maintain a continuous liquid film. A greater total time was required when the withdrawal was made rapidly; 3 minutes were required for substantially complete drainage in the latter case. The difference in time requirements between slow and rapid withdrawals is ascribed to the effect of surface tension acting at the meniscus. Following the conclusion of the experimentation, the use of wetting agents in the confining liquid was reported.[8] Their use should speed up drainage and require less frequent cleaning of the burette.

It has been suggested that dust-bearing gases be filtered through glass wool to aid in maintaining a clean burette surface.[7]

Temperature-Volume Effects.

The water jacket surrounding the burette and the confining liquid contain altogether about 300 c.c. of water, whose heat capacity is about 10,000 times that of the gas sample. It is therefore to be expected that introduction of hot gas would not affect the volume measured *if sufficient time were allowed for the gas to cool to the temperature of the burette.* To demonstrate the validity of this observation, the burette was rapidly flushed with successive samples of hot gas at about 350° F. Approximately 100 flushings were necessary to raise the tem-

[8] White, I.E.C. Anal. Ed. 12, 550, (1940).
[7] Severns and Degler, "Air, Steam and Gas Power," p. 99. John Wiley & Sons, New York. (1933 Ed.).

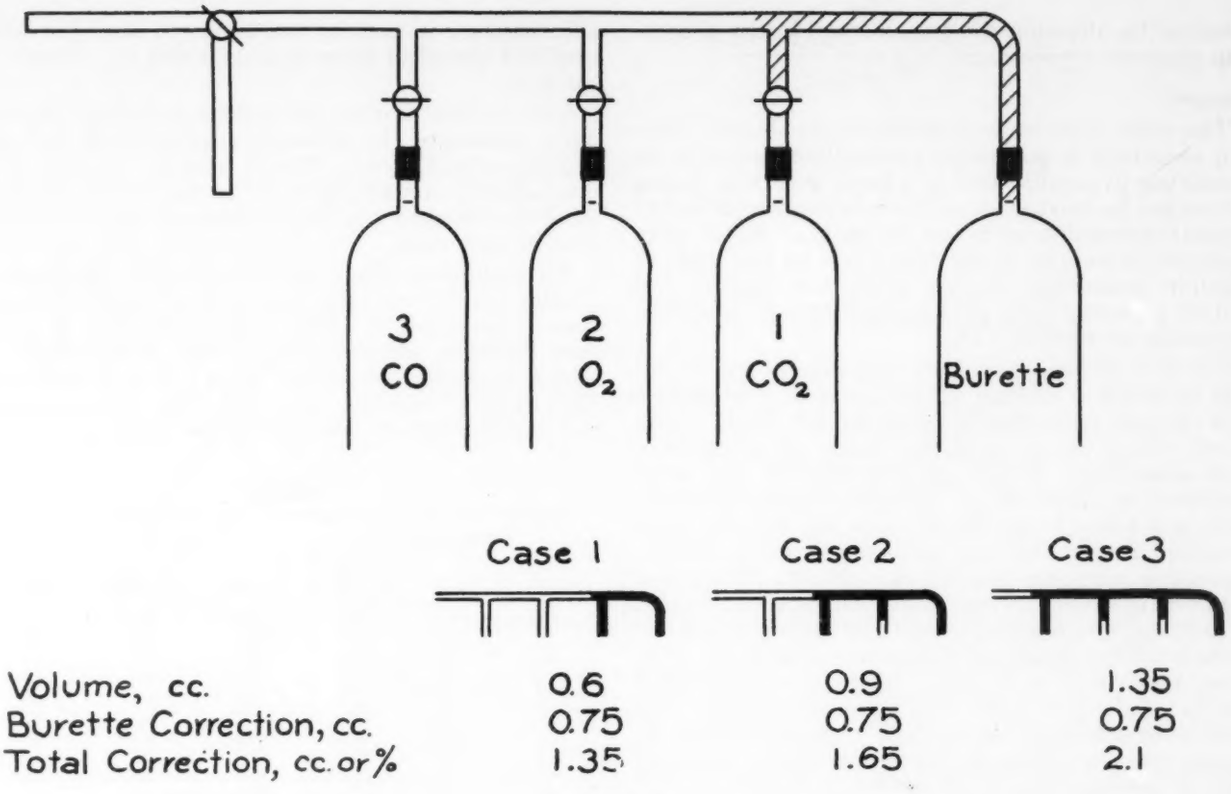


FIGURE 1

perature of the water jacket 0.5° C. Measurements on gas sampled at this same temperature after rapid withdrawals showed shrinkage of more than 1 c.c. 3 minutes later, which was the approximate time needed for establishing thermal equilibrium and complete drainage. Further experiments demonstrated that the procedure of drawing in the sample throughout a 30-second interval followed by a 30-second wait invariably gave a constant volume; probably because of more efficient cooling.

It is obviously necessary to maintain a constant jacket temperature during a test by keeping the instrument away from heat or cold, since a variation of 1° C. in jacket temperature produces an error of 0.3 percent.

Volumetric Corrections.

The conventional design of glass manifold with sampling stopcock on the end opposite to that of the burette causes the manifold to be completely flushed out by each new sample. The "capillary" tubing actually contains an appreciable volume. As a representative illustration, suppose that the burette, manifold and connection volumes total 102 c.c. and that the gas contains 10 percent CO_2. The CO_2 analysis would be 0.2 percent high. Calibration is therefore necessary to eliminate error.

The burette which was purchased from a reputable supply house was found to contain 100.48 c.c. with 0.31 c.c. of the error in the graduated portion. An additional volume of 0.25 c.c. was contained in the burette connection tube. Calibration of the capillary manifold gave the data shown in Figure 1. A typical flue gas would test 0.1 percent high in CO_2 and 0.2 percent high in O_2 without manifold corrections. (Alkaline pyrogallate also absorbs the CO_2 trapped between stopcocks.)

Once the burette, connection, and manifold tubing volumes have been determined, arithmetical correction of each analysis can be avoided by starting with a sample volume which totals slightly over 100 c.c. for Case I and slightly less than 100 c.c. for Case II. (In this instance the indicated volume of the sample should be 98.5 c.c.; actually 100.5 c.c.)

Confining Liquid and Vapor Tension

Mercury with a few drops of acidified water on its surface in the burette is the best confining liquid. However, it adds considerable weight to an instrument which is usually carried about and represents a considerable loss if spilled.

Although carbon dioxide and oxygen are somewhat soluble in acid solutions, such confining liquids become partially saturated with these gases and solution and release of them during an analysis is less than O.1 c.c. A number of tests on a flue gas sample gave identical results when using the following confining solutions: 20 percent NaCl, 0.02 N HCl, and 0.07 N HCl. Analyses of oxygen in air were made with these liquids and with pure water, all giving check results. The alkaline pyrogallate (48 percent KOH) used had a very low vapor tension compared to water, hence it is concluded that for proper sampling and measuring technique, the gas becomes resaturated in the burette and vapor tension effects need not be considered.

Reagents and Absorption Rates

The absorption pipettes were of the simple glass tubing-packed type. These do not give as rapid absorption as the bubbler and more highly developed types, yet are much less expensive and at a sacrifice in speed of analysis yield accurate results. The procedure in absorbing gases was to fill the pipette slowly in about 20 seconds, then immediately start transfer of the gas back into the burette, taking 30 seconds for the return operation. This gave the dependable measurements discussed in the first section of the article. When using these low transfers, no appreciable increase in absorption per pass was

obtained by allowing the gas to stand in the absorption pipette.

Oxygen.

The most common and generally satisfactory oxygen absorbent is potassium pyrogallate, prepared by dissolving pyrogallic acid in a large excess of strong potassium hydroxide. A solution which contained 10 percent pyrogallic acid and 40 percent KOH gave analyses of oxygen in air 0.4 to 0.5 percent low. A solution containing about 8 percent pyrogallic acid and 48 percent KOH gave a consistent 20.9 percent oxygen in air freed of CO_2.

The general procedure cited by Drakeley and Nicol[3] was followed in making up the reagent: The pipette was charged with 150 c.c. of 55 percent KOH (saturated) which was covered with a few c.c. of paraffin-base mineral oil. Fifteen g. of pyrogallic acid were dissolved in about 10 c.c. of water (saturated solution) and added to the KOH under the oil by a long-stemmed funnel. Mixing was completed by slowly aspirating nitrogen through the pipette. Absorption data obtained with air are shown in Figure 2. No loss in activity was apparent after the solution had absorbed 350 c.c. of oxygen, and it was still giving complete absorption in 7 passes after having absorbed 700 c.c. of the gas. (Over 4½ volumes of oxygen per volume of solution.) More than 7 passes will be required when working at low temperatures, since the rate of absorption is considerably slower.

The authors of the article cited conclude that solutions dilute in KOH give off CO, and the low results obtained when using a solution containing 40 percent KOH may be explained thereby. This point was not further investigated.

Carbon Dioxide.

A 40 percent KOH solution was found to be perfectly satisfactory for absorption of carbon dioxide. Absorption was complete in four passes. No noticeable decrease in activity had occurred after the solution had absorbed more than 10 times its volume of the gas.

Pure carbon dioxide was generated by heating sodium carbonate. To simulate conditions of flue gas analysis, this CO_2 was diluted with air to make definite samples containing 14 to 16 percent of the gas. Analyses checked calculated compositions to 0.1 percent in each case.

An additional check on both oxygen and carbon dioxide results was afforded by analyzing flue gases from combustion of a natural gas consisting of fairly pure methane whose ratio of atoms of hydrogen to atoms of carbon calculated from a low-temperature fractionation analysis was 3.80. The Orsat results and calculations are summarized in Table 1.

TABLE 1

ANALYSIS					
% CO_2	% O_2	% N_2 (by diff.)	$O_2 \equiv N_2$	$O_2 \equiv H_2O$	H/C
9.0	4.8	86.2	22.8	9.0	4.0
8.4	6.2	85.4	22.6	8.0	3.8
8.4	6.3	85.3	22.6	7.9	3.7
8.3	6.5	85.2	22.5	7.7	3.7
8.3	6.5	85.2	22.5	7.7	3.7
8.2	6.3	85.5	22.6	8.1	4.0
8.2	6.7	85.1	22.4	7.5	3.7
8.1	6.5	85.4	22.5	8.0	4.0
8.0	6.9	85.2	22.5	7.7	3.9
7.9	6.8	85.3	22.5	7.8	4.0
7.8	6.7	85.5	22.6	8.1	4.1
7.7	7.2	85.1	22.4	7.5	3.9
7.4	7.9	84.7	22.4	7.1	3.8
5.5	11.3	83.2	22.0	5.2	3.8
5.4	11.5	83.1	22.0	5.1	3.8
5.3	11.6	83.1	22.0	5.1	3.9
					Av. 3.87

No carbon monoxide was found. This is a severe test, since an error of 0.1 c.c. each in O_2 and CO_2 in the same direction affects the H/C value by about 0.2.

Carbon Monoxide.

The cuprous chloride reagent made up with Cu_2Cl_2, HCl and metallic copper is generally re-

[3] Drakeley and Nicol, **J.S.C.I. 44**, 457T, (1925).

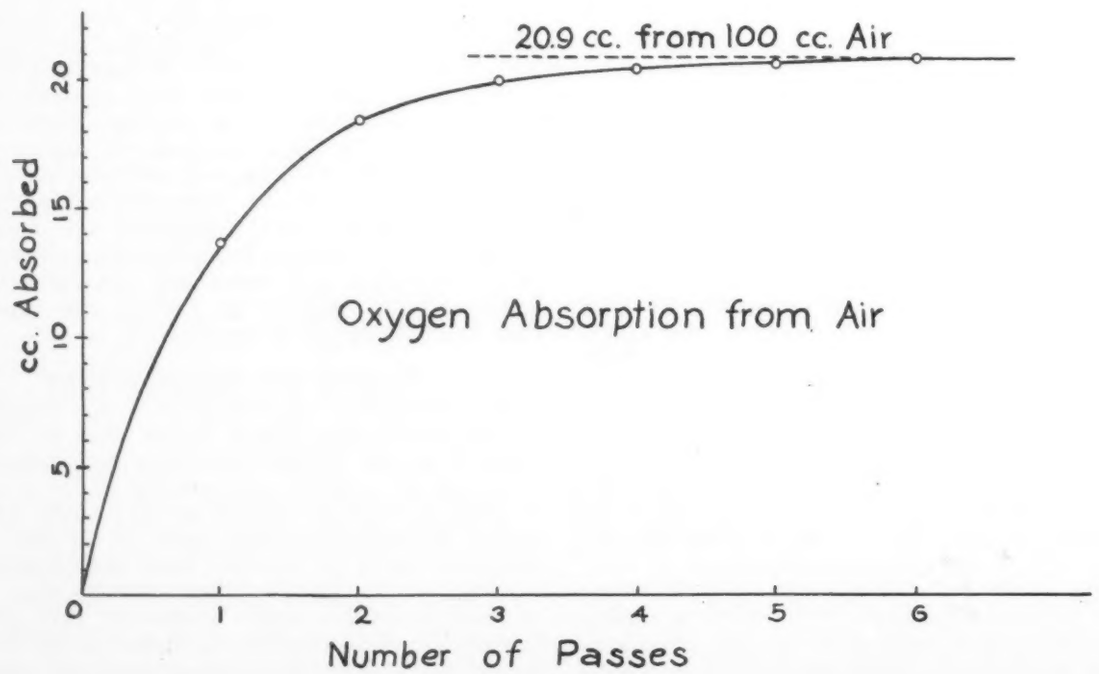


FIGURE 2

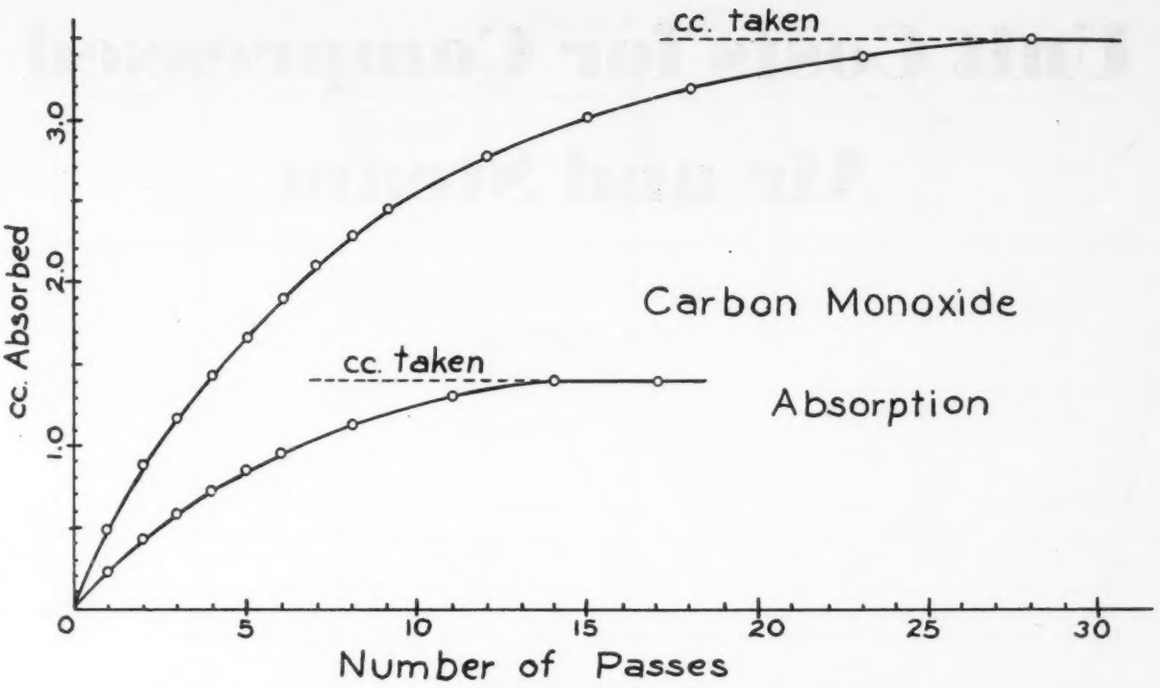


FIGURE 3

garded as satisfactory,[1, 5, 6] and will keep indefinitely. A quantity was made up by Engelder's procedure[4] with HCl of density 1.12, using 22.5 g. of Cu_2Cl_2 to 150 c.c. of acid, and about 100 g. of copper wire placed in the pipette. Brown coloration of the solution (indicating incomplete reduction) disappeared after one day's standing.

Carbon monoxide was prepared by adding formic acid drop-wise to concentrated sulphuric acid. Small, measured quantities of the gas were diluted with air and analyzed. The results are given in Table 2.

TABLE 2

Vol. Air c.c.	Vol. CO Taken * c.c.	Vol. CO Absorbed† c.c.	No. Passes to Const. Vol.
96.2	1.6	1.4	15
97.1	0.7	0.6	15
98.0	1.7	1.7	17
98.2	1.2	1.0	15
94.7	3.7	3.5	30
98.6	1.0	1.0	15

* Probably contain small amounts of air.
† CO_2 and O_2 absorbed first in usual manner.

Plots of the fifth and sixth analyses are shown in Figure 3.

Obviously, CO is absorbed very slowly. This is not unexpected in view of the reportedly low total absorptive capacity of the solution.[2]

Further analyses exhibited a marked decrease in rate of absorption, although only nine c.c. of CO had been absorbed up to that point. The authors are of the opinion that confusion exists between slowness of absorption, quantitative absorption, and total absorptive capacity. Gas samples after CO absorption showed no loss after passing into the KOH pipette, and a measured sample of nitrogen showed no volume change after passing into the carbon monoxide absorption pipette. It is therefore concluded that if acid Cu_2Cl_2 solution is not allowed to become completely exhausted:

(a) HCl vapor causes no error.

(b) Carbon monoxide is not released.

(c) A pipette containing 150 c.c. of the Cu_2Cl_2 reagent should be renewed after it has absorbed 8 to 10 c.c. of CO for rapid, dependable results.

The data at hand indicate that about 10 passes are required for each c.c. of CO to be absorbed from a gas of low concentration, when using a fresh solution in the tubing-packed type of absorption pipette. There are several other CO reagents on the market, most of which are less satisfactory than acid Cu_2Cl_2 from the standpoint of an occasional analysis. Proprietary reagents are usually all that is claimed for them, but manufacturers' advertisements may neglect to point out special limitations known to exist. For discussion of other absorption reagents, the following references are recommended:

1. **Gas Engineers Handbook,** pp. 490-540. (1934) McGraw-Hill.

2. Shepherd, **Bur. Stds. Jur. Res. 6,** 121, (1931) (Research Paper, **266,** Mar. 1931.)

[1] Australian Chem. Inst. and Proc. **5,** 201-6, (1938).
[2] Dennis, "Gas Analysis," p. 232. McMillan, New York (1920).
[4] Engelder, "Gas, Oil and Fuel Analysis," John Wiley & Sons, New York. (1937 Ed.).
[5] Matuszak, "Fisher Gas Analysis Manual," p. 6, Fisher Scientific Co., Pittsburgh.
[6] Moller, Z. Anorg. Allgem. Chem. **224,** 153-66, (1935). (C. A. **29,** 7848).

Unit Costs for Compressed Air and Steam

J. R. DARNELL

OCCASIONALLY one may hear some plant operator ask why it would not be better to use compressed air instead of steam for atomizing fuel oil. The best answer is that it costs too much to produce the required amount of compressed air. An efficient inside mixing type of fuel-oil burner requires from 0.10 to 0.30 pound of steam per pound of oil for atomization. In terms of steam output, the steam for atomization will vary from 0.7 percent to about 2 percent. If air were used, even though heated, it would require a greater amount than steam and in either case the cost would be prohibitive. Recently we read an article in which the author advocated the use of compressed air for soot-blowers for cleaning boiler tubes. Such usage, likewise, would be expensive.

To produce compressed air at 100 pounds gauge pressure at sea level requires, as an average, slightly over 0.2 brake horsepower per cubic foot of free air per minute in volumes equivalent to 1000 pounds per hour. The exact power requirement for a given volume and pressure will, of course, vary with the size and type of compressor. One pound of free air at 70° F. occupies approximately 13⅓ cubic feet, therefore to compress this amount of air, about 2.67 brake horsepower is required. If stated on the basis of 1000 pounds per hour, it would require 2670 brake horsepower or 1990 kilowatts. At a power cost as low as ½ cent per kilowatt hour it would cost $9.95 to produce 1000 pounds of compressed air per hour at 100 pounds pressure, exclusive of operating labor, water, maintenance and fixed charges. The high cost is unavoidable and is due to the excessive power consumed in the generation of heat as the air is compressed.

Figure 1 is representative of the power requirements of a single-stage reciprocating compressor for constant speeds at various pressures. One thousand pounds of air per hour is equivalent to 223 cubic feet per minute and the power required for this volume at 100 pounds pressure is 47.8 brake horsepower. This is equivalent to 0.215 brake horsepower per cubic feet per minute.

There are many operations in industrial plants where compressed air is almost indispensable, but wherever steam can be used, such as for oil atomization, compressed air costing more than 40 times as much, should be saved. Leaks in air lines and hose connections should be repaired without delay. Values in Table 1 show amounts of air wasted by various sizes of leaks and the approximate power cost of the air lost through such leaks. If a leak is discovered where the hose coupling has been broken and the air is escaping unhampered through the full opening of the hose, or a water drain valve in a line has been left wide open and air is escaping through the full size of the pipe, multiply values in Table 1 by 1.5 for whatever size opening corresponds.

Values in Table 1 were computed by a modification of a formula developed by S. A. Moss:

$$Q = 425 \frac{A C P}{\sqrt{T}}$$

where Q = air in cu. ft. per minute.
A = area of opening in sq. in.
C = 0.65 where flow is restricted as in defective threads and cracks in fittings.
P = gauge pressure plus 14.7 lb.
T = air temperature at 70° F. plus 460°.

An easily remembered rule is that for a given pressure the flow varies directly as the square of the diameter of the opening. For example, the flow through an opening one fourth-inch in diameter is four times as much as that through an opening one eighth-inch in diameter.

Steam Costs

Steam costs are variable and depend upon numerous factors. Considering a unit cost per 1000 pounds of steam, figures for various plants may range from 25 to 50 cents, depending upon costs for fuel, water, labor, maintenance, and fixed charges. Contrast the top figure of 50 cents with the price of approximately $10.00 for air.

Normally the fuel cost is the largest item of steam cost, averaging from 75 to 80 percent of the total. Water treatment and pumping costs may vary from 3 to 6 percent, operating labor will be about 7 to 8 percent, maintenance from 3 to 6 percent, and fixed charges about 3 percent.

If the feed water is not heated by waste heat, the fuel cost will increase and if the water is treated the cost for this operation will be higher and maintenance lower than where hard water is used. If the water is not treated, the increased maintenance cost probably will be much more than the cost of treating.

Fuel cost, of course, depends upon the kind, equipment for firing and the resultant efficiency. Where coal is used the cost for this item, starting with the price f.o.b. mine, increases with freight and handling charges. For example, if 1¼-inch screenings are to be used for chain grate stoker firing, the price at the mine may be $2.50 per ton, but when freight and

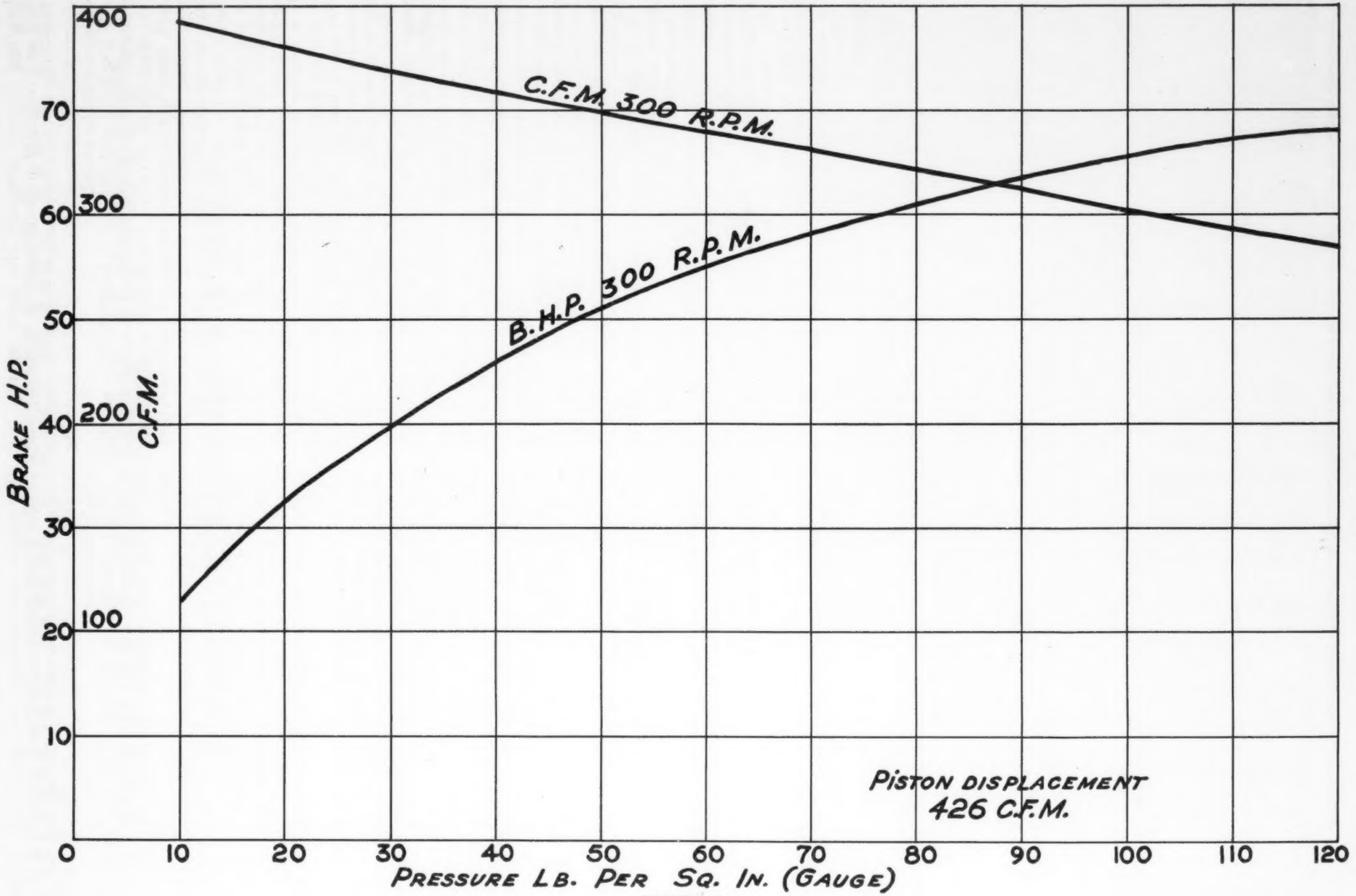


FIGURE 1

Power Requirements of a Single-Stage Reciprocating Compressor for Constant Speeds at Various Pressures

handling charges are paid, the price for this fuel put into overhead bunkers may be $4.00 per ton. There also will be a power charge, either for steam or electricity for driving the stoker. Ash handling charges must be added.

If powdered coal firing is to be used, there will be power charges for pulverization and blowing the fuel into the furnace. If forced and induced draft fans are used, there will be power charges for their operation, and where powdered coal firing is employed there may be appreciable maintenance charges for the induced draft fan due to the abrasive action of the ash in the flue gases. If some type of dust catcher is installed, either of the dry or wet type, there will be fixed and maintenance charges for this equipment. If a washer is used, it probably will be necessary to provide heated air to raise the temperature of the flue gases leaving the washer in order to prevent excessive corrosion of the induced draft fan, breeching and stack, if the latter is steel.

Fuel-oil firing requires less investment and maintenance charges, but of course there will be pumping charges both from cars to storage tanks and from the tanks to the burners. If the oil is viscous at low temperatures, steam heating coils may be required in the storage tank, and this item of cost will need to be figured. There also will be steam costs for atomization if such type burners are used, and the slight loss in efficiency due to heat carried away by the steam should, perhaps, be considered. Mechanical burners will have a higher investment cost and higher pumping cost because of higher pressure required at the burner.

With gas firing the cost of the burners will be higher and maintenance lower.

Maintenance costs for brick-work generally increase with increased furnace temperatures, and one might expect a larger figure for this item with oil and gas firing, but the slagging action of the ash when firing coal, even at a lower average furnace temperature, causes a spalling action which probably results in a higher maintenance cost for brick-work with coal firing than with oil and gas. Steam cost for operating the soot-blowers also must be figured.

Direct operating labor, besides the wage rate, depends upon the ratio of operators to boilers and firing equipment. For example, a plant which has an output of only 50,000 pounds steam per hour, say from one boiler with another unit as a stand-by, will require at least one operator per shift. If oil or gas is used for firing and there is automatic regulation of fuel and water, this same operator can look after three or four boilers as well as one. Therefore, for the cost of one operator, the plant could generate 150,000 to 200,000 pounds of steam as easily as 50,000 pounds. There is always an optimum ratio of operators to boilers, depending upon the kind of fuel and type of equipment.

Fixed charges, as in any plant, are figured on depreciation of buildings and equipment, taxes on real estate, and insurance on equipment and employes.

Not all of the water pumped to the boilers is turned into steam, so that meter figures for water will not check with the steam flow meter, even though both steam and water meters are constantly checked for accuracy. All boilers must be blown down at least at stated intervals, and where water softeners are used it may be advisable to have continuous blowdown.

Cost of steam in the mains leaving the boiler house does not represent the ultimate cost in plants where steam is used for process work and must be carried for long distances. Condensation losses, even with good insulation of the piping, will increase the cost at the points of use. Also there may be leaks in fittings which, although apparently negligible at a given point, may amount to considerable in the aggregate.

For example, using Napier's formula, which is fairly accurate for rough calculations, even a leak the equivalent of a hole 1/32-inch in diameter, if found at several places in the plant, may amount to an appreciable figure over a yearly period. This formula is:

$$W = P \times A \times 51.5$$

where W = Pounds of steam per hour.
P = Steam pressure, lb./sq. in. absolute.
A = Area of the hole in sq. in.

If the steam pressure in the line where the leak occurs is 150 pounds, a leak which is the equivalent of a hole 1/32-inch in diameter will have an area of .0007 square inch and

$$W = 165 \times .0007 \times 51.5 = 5.95 \text{ lb. per hour.}$$

If the plant operates 24 hours per day and 335 days per year, the steam loss at this one point will be:

$$5.95 \times 24 \times 335 = 48{,}000 \text{ lb. per year.}$$

A tour of the plant may disclose 15 or 20 such leaks which at a cost of 35 cents per thousand pounds, might amount to over $300.00 per year. If the management would add half of that to the chief's salary for persuading the maintenance crew to stop such leaks, everybody would be satisfied.

TABLE 1

Approximate Loss of Compressed Air by Leakage in Fittings and Hose Connections

Equivalent Diameter of Holes in Inches

Gauge Press. Lb. Per Sq. In.	1/32		1/16		1/8		1/4		3/8		1/2		5/8		3/4		7/8		1	
	Cu. Ft. Free Air Per Min. and Corresponding Power Cost Per Day*																			
35	0.46	$0.49	1.82	$1.96	7.30	$7.87	29.2	$31.54	65.7	$70.96	117	$126	183	$198	263	$284	358	$387	468	$505
40	0.50	0.54	2.01	2.17	8.04	8.68	32.1	34.66	72.4	78.19	128	138	201	217	289	312	394	426	512	553
45	0.55	0.59	2.20	2.37	8.76	9.46	35.2	38.02	79.3	85.66	140	151	220	238	316	341	430	464	562	607
50	0.60	0.65	2.38	2.56	9.56	10.32	38.1	41.15	86.0	92.88	153	165	238	257	343	370	466	503	610	659
55	0.64	0.69	2.56	2.76	10.24	11.06	41.0	44.28	92.2	99.58	164	177	256	276	368	397	502	542	656	708
60	0.69	0.74	2.76	2.98	11.04	11.92	44.2	47.74	99.4	107	177	191	276	298	398	430	542	585	708	765
65	0.73	0.79	2.92	3.15	11.68	12.61	46.7	50.44	105	113	187	202	296	320	426	460	572	621	748	808
70	0.78	0.84	3.12	3.37	12.48	13.48	49.9	53.89	112	121	200	216	313	338	449	485	612	661	800	864
75	0.83	0.89	3.32	3.56	13.28	14.34	53.1	57.35	119	129	212	229	331	357	476	514	650	702	849	919
80	0.87	0.94	3.48	3.76	13.92	15.03	55.7	60.16	125	135	223	241	350	378	503	543	682	737	892	963
85	0.92	0.99	3.68	39.7	14.72	15.90	58.9	63.61	132	143	236	255	369	399	530	572	723	781	944	1,020
90	0.96	1.04	3.85	4.15	15.39	16.62	61.6	66.53	138	149	248	268	388	419	559	604	755	815	992	1,071
95	1.01	1.09	4.04	4.36	16.16	17.45	64.6	69.77	145	157	260	281	406	438	585	632	795	859	1040	1,123
100	1.06	1.14	4.24	4.57	16.96	18.32	67.8	73.22	152	164	271	293	425	459	610	659	833	900	1084	1,171

*Electric power costs, based on ½ cent per K.W. hour, are for 24 hour day and are equivalent to cost of $9.95 per 1000 lb. or $0.00075 (about 1/13 cent) per cu. ft.

Topping and Cracking Get 58 Percent Gasoline Recovery From Illinois Crude

YIELD of 58 percent, 400-end-point gasoline, by topping and cracking is the record of Pana Refining Company, Pana, Illinois, which is running on crude from the Loudon field. The plant, which was moved from East Texas last year, has throughput of 4000 barrels on the topping side, with 1800 barrels of capacity for the cracking side.

This plant, one of the few with cracking facilities and running solely on Illinois crude oil, also gets a yield of 12.5 percent of distillate and tractor fuel; 6 percent of kerosine, 19 percent of heavy fuel oil, with 4.5 percent loss.

Both straight-run and cracked gasolines are treated, a copper-contact process for the former and a different copper process for the latter. The kerosine output is treated with doctor solution.

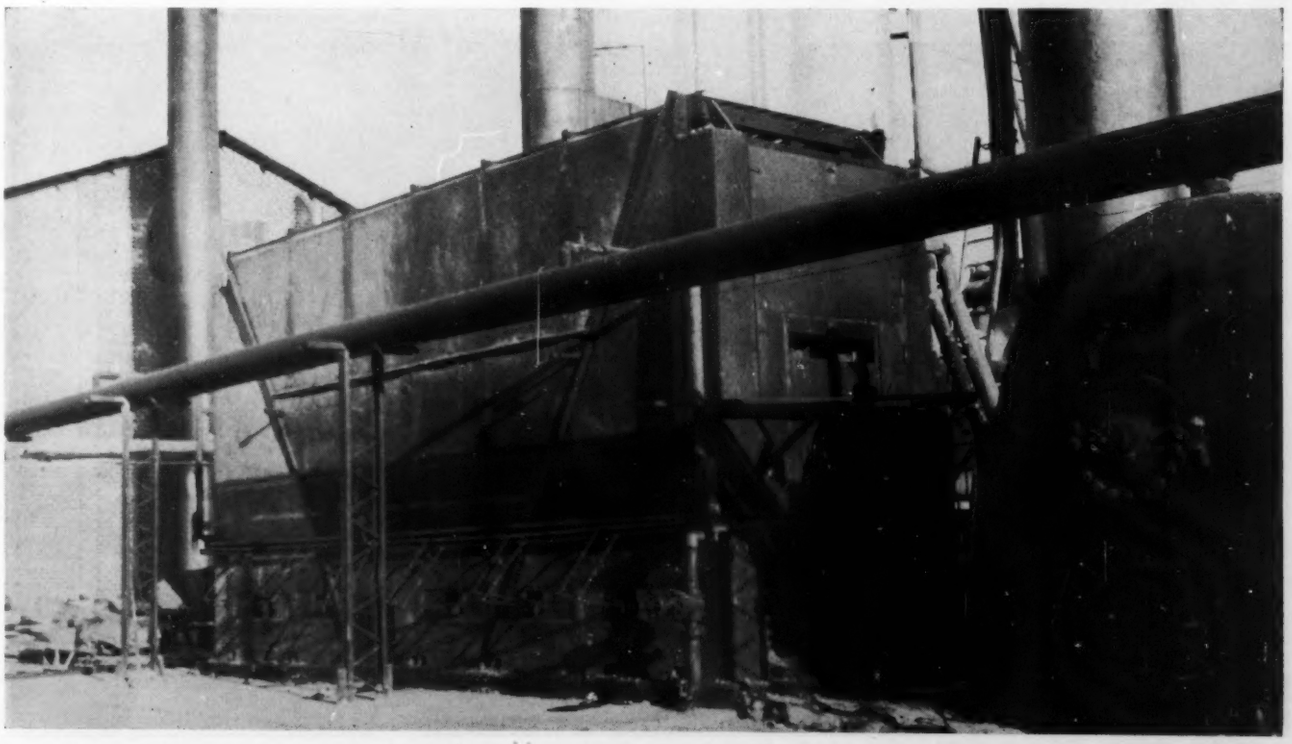
Yields, treating and the blending of gasolines for gaining required grades of motor fuel are considered typical of what the industry is getting from Illinois crude oil.

When the plant was dismantled in East Texas, George Pfau, vice president, made plans for assuring easy rebuilding in Illinois. Flanged fittings, piping, valves and other parts were numbered. The result was that the plant was set up at Pana exactly as it had been built. Moving and reassemblying was completed in five months.

The tube still for the cracking plant was built with a double side firing control, upshot in operation, using natural gas for fuel in Texas. When erected at Pana, the furnace was raised and redesigned to burn either fuel oil or gas. Oil is used to start up after shut down, and process gas after coming on stream.

The straight-run furnace was designed by company engineers and has a split flow with a single side firing control, topped crude entering two sections of tubes but joining at the transfer line. Fresh crude enters the still at two points, and leaves at a temperature of 600°F. with a pressure of 30 pounds in the fractionating towers.

Two columns are used in series, the first to manufacture 400-end-point gasoline, and the other to pro-



The straight run still was designed by company engineers especially for the installation at the Pana plant.

duce distillate and kerosine. The first column is controlled for top temperature with a 1:1 reflux, using bottoms of the second tower pumped back over the top plate.

Yield of the topping plant is as follows:

Crude Charge	Percent Yield	Quantity
4,000 Barrels:		
Gasoline 400 ep.....	33.....	1,320 barrels
Kerosine 500 ep.....	6.....	240 barrels
Distillate zero 38°A.P.I..	10.....	400 barrels
Topper crude 21°A.P.I...	50.....	2,000 barrels
Loss	1.....	40 barrels
	100	4,000 barrels

The topped crude is charged directly to the cracking plant from the topping unit with a pump pressure of 480 pounds, and leaves the tube still transfer line at 923°F. The reaction chamber pressure is held at 250 pounds, and the fractionating column at 75 pounds, gauge. The yield of products from this operation, based on the topped crude charge is as follows:

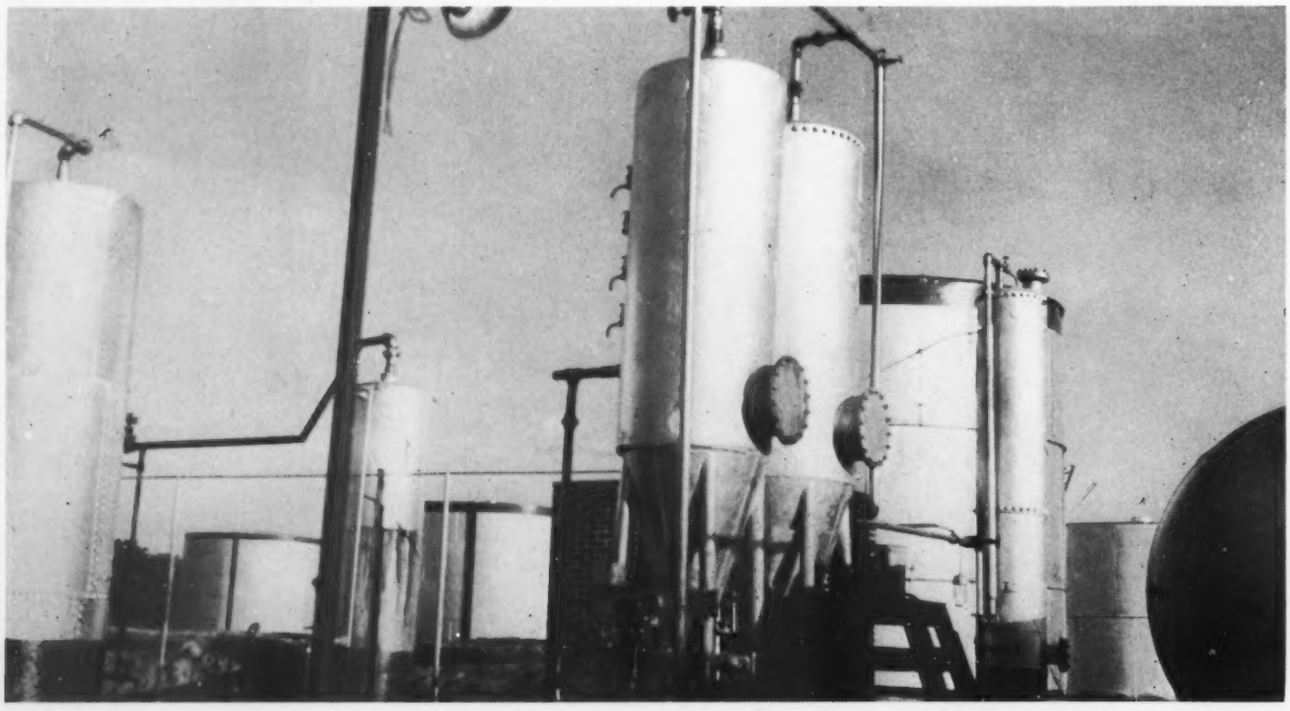
Charge	Percent Yield	Quantity
2,000 Barrels Topped Crude:		
Gasoline, 400 ep.....	50.....	1,000 barrels
Distillate	5.....	100 barrels
10/11 250 vis fuel.....	38.....	760 barrels
Gas and Loss.....	7.....	140 barrels
	100	2,000 barrels

The straight-run gasoline contains both H_2S and mercaptans. The mercaptan content is .013 which is converted in a copper treating plant. This gasoline is pumped through a horizontal tank containing caustic in solution which is recycled with a jet at the inlet to obtain circulation and to obtain intimate contact with the chemicals. The caustic solution is used over and again until spent, but the gasoline makes only one pass through this part of the treating process. It leaves at the top of the vessel and enters a second of like size to provide sufficient settling time for separation of the caustic before the gasoline enters the copper-treating plant.

This copper-treating plant makes use of commercial oxygen obtained in standard size drums containing 220 cubic feet, which is employed to reactivate the copper continuously. Two vertical tanks with conical bases are used as contact vessels, each containing only about 20 pounds of treating compounds, consisting of 10 pounds of copper chloride and 10 pounds of 200-mesh clay. The gasoline is pumped once through either of the columns with a motor-driven centrifugal pump, which pumps the gasoline from the settling vessel to the conical connection of the vertical contact vessel.

A jet at this point recirculates the copper chloride-clay, suspended in the gasoline to obtain intimate contact in a slurry form. The oxygen is released from the drums by a manifold connection and enters the gasoline stream at a point immediately upstream from treating compound slurry jet. The requirement of oxygen is about 220 cubic feet for each 1200 barrels of gasoline. The copper chloride-clay compound is added to the unit through a lubricator drum at the rate of about 2 pounds per day—1 pound of copper chloride and 1 pound of 200-mesh clay dry mixed outside, and put into the lubricator drum through a funnel. The gasoline leaving this treater is then sweet and non-corrosive.

The kerosine is treated with doctor solution, but the distillates, sold as tractor and Diesel fuel are not contaminated with sulfur compounds in quantities large enough to demand treating. The cracked gasoline is washed with a caustic solution prior to being treated by another type of copper sweetener that contains a two-phase treatment; one for removal or sulfur compounds, and the other to neutralize or remove the small trace of copper carry over. Inhibiting and leading for standard quality gasoline is done immediately; the inhibiting agent introduced at the inlet of the transfer centrifugal pump, and the lead after blending. Ethyl gasoline is made by using the required percentages of straight run, cracked and natural gasolines and the distinctive dye.



Hopper bottomed vessels are used for copper treating contact.

The Refiner's Alloy

WELDON L. ARCHER

TRULY this is an age of alloys. All modern activities are based to a greater or lesser extent on the use of steels to which small amounts of alloying ingredients have been added to obtain special properties. Certain conditions of operation demand particular ability of an alloy. Indeed the successful solution of a three-fold problem of the refiner by 5-percent-chromium steel (sometimes known as 4- to 6-percent-chromium steel) constitutes a most interesting story of metallurgical development.

As new processes progressed from the laboratory to the pilot plant to the refinery, increases in both temperature and pressure were noted. Greater operating efficiency, as measured by more gasoline per barrel of oil, was the goal and more severe operating conditions were the means of attaining that goal.

All the newer refining methods combined to bring three distinct problems to the fore. And a metal was sought to solve this difficult trio. Resistance to corrosion, resistance to scaling or oxidation and good creep strength at elevated temperatures defined the needs of the industry. Any one of these problems was bad enough. But to the account of the refiner and his metallurgist goes the credit for the evolution of a steel that satisfied all three of these severe demands.

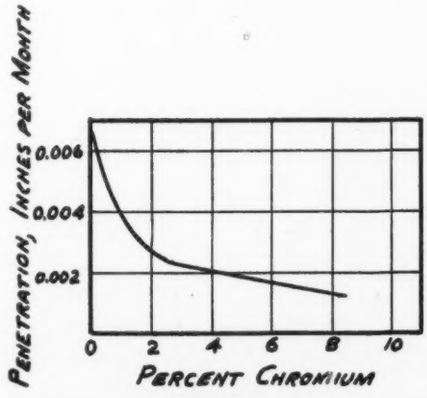


FIGURE 1

Relation of corrosion rate and chromium content of steels when handling certain corrosive crudes at high temperatures and pressure.

Had the satisfactory completion of this investigation taken place over a long period it would still have been acclaimed as a monumental contribution to the industry. However the facts of the case are that less than 15 years were consumed in bringing about this advance. Now the 5-percent-chromium alloys are to be found not only in the tube stills for which they were first designed but also in pump parts, valve gates and stems, bubble caps, bubble trays and tray support angles, burners and many other miscellaneous uses about the refinery.

The evolution of the 5-percent-chromium alloy as the proper one to use in refining practice resulted from a careful scientific investigation based upon service results. From carbon steel, which by the way gave excellent results within its safe working limit of 950° to 1000° F. while handling the "sweet" crudes of the Mid-Continent and Eastern fields, a great jump was made to the 18-8 stainless steels. These latter steels gave very encouraging results but the refiner felt the material might be too good. Long service life was had at great expense. Very often the

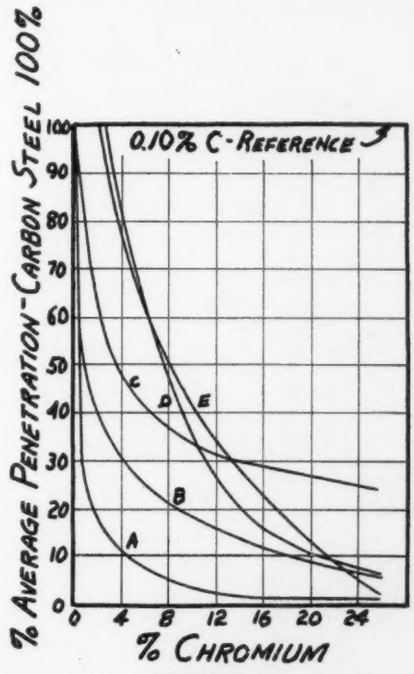


FIGURE 2

Corrosion resistance of chromium alloy steels (0.05 to 0.07 percent carbon) compared with 0.10 percent carbon steels. Curves D and E are laboratory tests.

life of the material was much greater than the normal span of the process. Obsolescence, the ever-present bugaboo of the refinery amortization schedule, overtook the expensive stainless metal before it passed the time of adolescence. Therefore a less noble material, possessing an adequate rather than an everlasting service life, was sought.

Five-percent-chromium steel proved to be the answer after a series of exhaustive tests disclosed the relationship between chromium content and the rate of corrosion. Figure 1 illustrates the results of this investigation as first reported by Dixon. From a

study of this curve a range of 4- to 6-percent-chromium was decided upon.

Immediately following the selection of this range thousands of tubes were manufactured for the petroleum industry using the 5-percent-chromium analysis. Additional corrosion studies followed adding the graph of Figure 2 to the existing knowledge. Studies of 15 different alloys were conducted in 10 separate refineries to give the five curves:

A—Service Tests in Evaporators—Vapor Phase
B—Service Tests in Oil Cracking Tubes—Liquid Phase
C—Service Tests in Oil Reaction Chambers—Liquid Phase
D—Hydrogen Sulfide Tests—168 Hours at 850° F.
E—Oxidation Test—6 Weeks at 1275° F.

Of course this was the only proper way in which corrosion data could have been gathered. As long as corrosion remains the peculiar mechanism that it is, or at least until we find the key to the mystery of corrosion in action, empirical tests under actual service conditions afford the only approach to the problem of what material to use where.

Corrosion resistance was estimated at from four to ten times that of ordinary steel while resistance to oxidation was determined to be about three times that of low-carbon steel. The latter function of the chromium addition to steel is shown in Figure 3. Then, too, the chromium served to increase the strength at elevated temperatures.

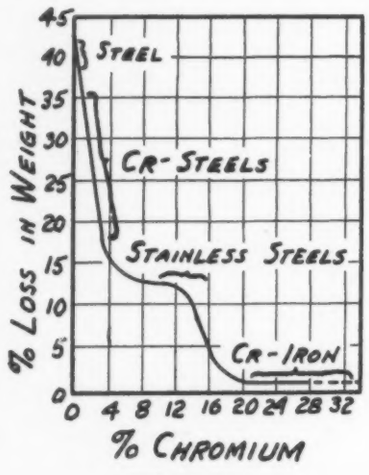


FIGURE 3
Loss of weight in half inch cubes by oxidation at 1000° C. for 48 hours.

Ordinary 4- to 6-percent-chromium steel was restricted to 1100° F. maximum operating temperature. Even this limit would not have caused the early downfall of the straight alloy in tube still applications. But the introduction of the low-chromium alloy into refineries by the thousands of tons brought with it much service information. Long-time operations at high temperatures appeared to be in line with early investigations. Every once in a while a tube would be found split after the cleaning operation.

Since the splitting problem appeared to be the greatest in the northern refineries where cleaning was conducted at low atmospheric temperatures, it was felt that low impact strength was the answer. And so it was. Long service at elevated temperatures rendered the steel brittle at low temperatures. The impact of the cleaning tool fractured the tube. So preheating the tubes to about 300° F. was tried as a remedy.

TABLE 1
Analysis of a Typical 5 percent Chromium-Molybdenum Steel

	Percent
Carbon, max	0.15
Manganese, max	0.50
Silicon, max	0.50
Phosphorus, max	0.03
Sulfur, max	0.03
Chromium	4.00—6.00
Molybdenum	0.45—0.65

Although preheating the tubes eliminated the cracking danger, a new answer appeared on the horizon. Five-percent-chromium steel to which had been added 0.5 percent of molybdenum or 1.0 percent of tungsten was introduced. By making the simple alloy somewhat more complex all danger to life and property was removed. Cracked tubes as a result of the cleaning activities disappeared.

Now some laboratory tests have been devised to measure the susceptibility of these chromium steels to so-called temper brittleness or the lowering of impact strength after long periods at the operating temperatures. As a result of these tests, molybdenum bearing steels appeared to be less subject to loss of impact than the tungsten analysis. Actual service tests of both materials did not show up any weakness in either.

Cost must be the determining factor in the application of the two alloys. Almost all the tubes are made from the molybdenum variety while valves and valve parts of the tungsten specification are common. Since sound engineering forces the user to place more emphasis on service life than on laboratory tests, notwithstanding the tremendous importance of laboratory investigations in our complex civilization, the refiner may use either the molybdenum or the tungsten type with the utmost confidence in its behavior.

Before going on to some of the other modifications of the 5-percent-chromium steels a brief consideration of some of the chemical and physical properties of the molybdenum-bearing variation appears to be in order. First the analysis will be considered. Table 1 lists a typical specification.

In Table 2, are presented the quick tensile properties of this material at various elevated temperatures. And in Table 3 are given the creep data at elevated temperatures. One advantage of the alloy containing molybdenum is the increase permitted in maximum operating temperature. Ordinary 5-percent-chromium steel was restricted to a maximum operating tem-

TABLE 2
Quick Tensile Properties of 5 Percent Chromium-Molybdenum Steel

Testing Temperature °F.	Tensile Strength p. s. i.	Elongation % in 2"	Reduction of Area %
Room	75,950	33.5	69.3
800	60,500	28.5	66.8
900	53,350	36.5	73.9
1000	45,350	46.0	83.2
1100	31,700	60.0	90.2
1200	24,450	69.5	93.7
1300	17,800	78.5	96.6
1400	11,370	78.0	98.8
1500	11,890	22.5	73.5
1600	12,940	41.5	50.2
1700	9,950	41.5	49.5

TABLE 3

Allowable Creep Stress of 5 Percent Chromium-Molybdenum Steel

Testing Temperature °F.	Creep Stress in p. s. i.	
	0.10%/1000 Hr.	0.01%/1000 Hr.
900	15,250	11,500
1000	10,100	7,600
1100	5,850	3,200
1200	2,800	1,700

perature of 1100° F. while the addition of molybdenum raised the upper limit to 1200° F. One other property at elevated temperature, the impact strength, merits examination before the review of the physical properties of this alloy may be considered complete. This information is detailed in Table 4.

So much for the history, applications and physical properties of the 5-percent-chromium alloy. Since so many of the refinery adaptations of this material require welding for fabrication, maintenance and repair, notice must be given this aspect of the subject.

As is the case with most alloys, it will be found that the low-chromium types are readily welded. That appears to be a glib statement when the many difficulties that have been encountered in actual welding practice are recalled. Nevertheless proper procedure control will give very satisfactory results.

In the welding of 5-percent-chromium steel, as in the welding of any other material, general practice indicates the deposition of quality weld metal as near the properties of the base metal as is possible. That means that both the corrosion resistance and the physical properties of the base metal should be duplicated in the welded joint. When the higher cost of the alloy is brought into the picture, the need for greater care in fabrication may be appreciated even more.

The outstanding hurdle standing in the way of successful welding is the air-hardening tendency of the material. Chromium forces the heat affected zone, and sometimes the weld metal, into a hard and brittle condition as a result of the thermal and metallurgical changes encountered in the welding operation.

Preheating and maintaining the interpass temperature are the specific for this trouble. Whereas the materials usually encountered in alloy welding may be treated with heat to a temperature of no more than 400° F. to give good joints, the chromium alloys require higher temperatures. No less than 400° F. and more than 500° F. are best suited to the welding of this metal.

A metallurgical dodge has been developed to enable the fabricator to avoid this air-hardening tendency. By the use of elements that have an even greater affinity for carbon than has chromium the air-hardening tendency may be materially reduced and, in some cases, entirely removed. Columbium, tantalum and titanium have all been successfully included in chromium steels for this purpose. Of the three columbium has been employed the most extensively. Before going into a detailed discussion of the influence of columbium, the entire welding problem will be studied.

Three welding processes are available for the welding of the 5-percent-chromium steels. These are the oxy-acetylene process, the atomic hydrogen process and the metallic arc process. The gas welding method requires very close control when it is used. For a reducing or carburizing flame may add carbon to the deposit thus aggravating an already bad air-hardening propensity. On the other hand an oxidizing flame leads to the formation of chromium oxide and reduces the chromium content of the weld. Because chromium oxide is high infusible, remember it is an important constituent of high-temperature refractories, special fluxes capable of dissolving and floating out this impurity are required. Such fluxes are aavilable commercially.

The second method, the atomic hydrogen process, is subject to the same limitations that are encountered in its use for mild-steel welding applications. In general sheet metal is best welded by the atomic hydrogen process leaving the thicker metals for the metallic arc. While the hydrogen gas eliminates the necessity for fluxes and delicate flame adjustment, particular attention must be paid to the adjustment of the arc and gas to take complete advantage of the exothermic heat of the flame. Even where sufficient control is exercised, the cost is likely to be higher than that of the metallic-arc method.

The third, and most commonly used, method is the metallic arc. Here the selection of the proper electrode is of the utmost importance. Not only must the deposited metal possess the desired chemical and physical properties but also must the electrode be capable of easy manipulation. Chapman and Moses point out five important characteristics of the electrode. These are "(1) Analysis of the bare rod; (2) Fluxing qualities of the coating; (3) Difference in analysis between the rod and deposited metal due to loss of chromium and other elements and possible gain in carbon and nitrogen; (4) Ease of manipulation and physical characteristics of the bead, such as tendency to undercut or to form smooth fillets; (5) The homogeneity of the deposited metal as regards porosity or other inclusions."

Very often this analysis is selected for services where high stresses as well as resistance to corrosion are encountered in the specification. Then the weld metal is subjected to both radiographic examination and corrosion tests.

Welding practices calls for the completion of welds and subsequent annealing in the furnace as soon after welding as possible. Two distinct types of annealing are possible. True annealing is accomplished between 1575° and 1600° F. followed by a slow cooling of not more than 25° F. per hour through the critical range. The sluggishness of transformation explains the needs for such slow cooling. Or the subcritical anneal may be performed. In this case the annealing is accomplished by holding at 1400° F. for several hours (the length of time is a direct function of the thickness of section) followed by a very slow cool to 1200° F. Below this tempera-

TABLE 4

High Temperature Impact Strength of 5 Percent Chromium-Molybdenum Steel

Testing Temperature °F.	Charpy Impact in Ft.-Lb.	
	1 Hr. at Temperature	1000 Hr. at Temperature
85	81.3	....
500	68.7	77.0
600	72.5	80.7
750	75.0	73.3
900	64.5	52.0
1000	58.7	61.0
1100	54.3	56.0
1200	53.7	40.0

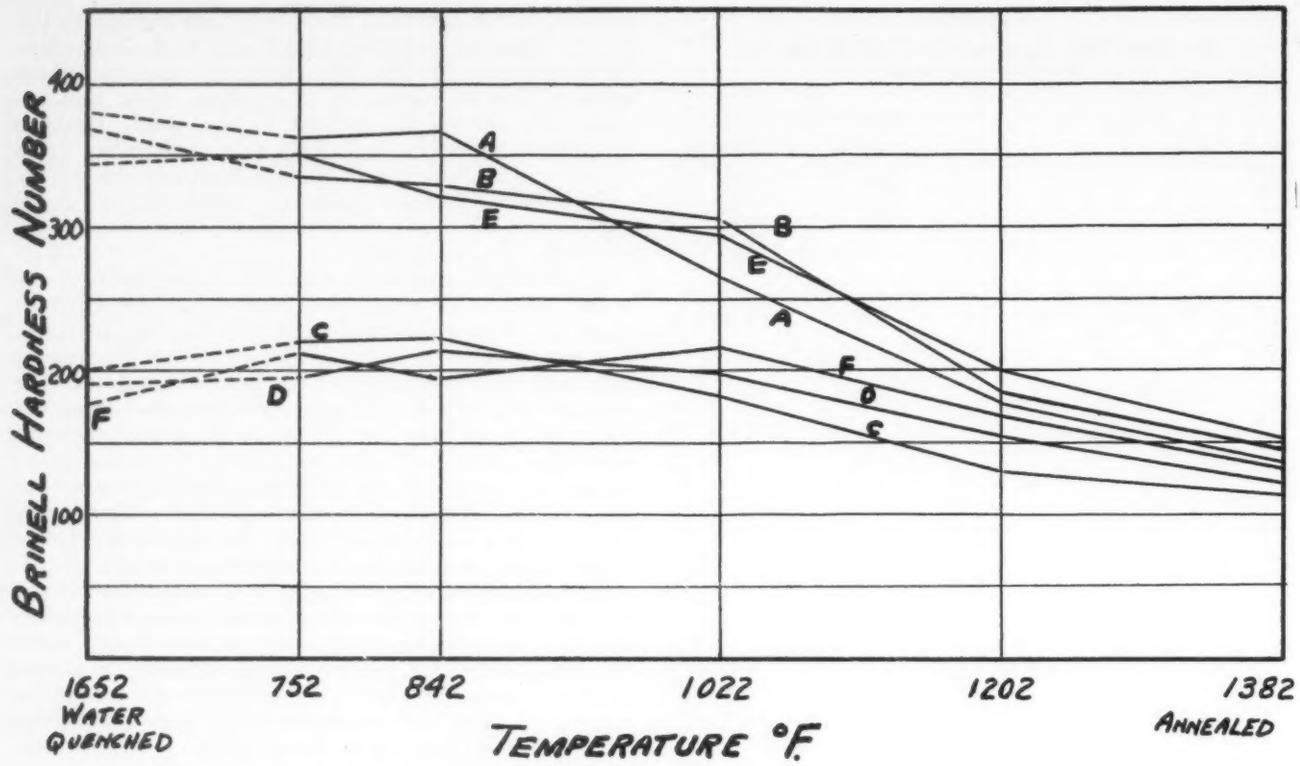


FIGURE 4

Hardness of various 5-6 percent chromium steels after water quenching from indicated temperatures.

ture the cooling may be done more rapidly as is the case with ordinary stress-relieving practice.

It is entirely possible that cracks might develop between the time the weld is completed and the annealing operation is undertaken. For this reason the general custom is to make all radiographic examination after the annealing is finished. Thus all defects may be discovered.

Although the x-ray will disclose many defects, resistance to corrosion is not among them. Special corrosion tests have been devised to evaluate the resistance of the weld deposit in a relatively short time. Generally the hydrogen sulfide test is performed on the 5-percent-chromium steels.

Now the columbium-bearing non-air-hardening steels will be examined. The influence of columbium may be observed in the hardness values obtained by water quenching the steels after holding for 700 hours at the temperatures designated. Of course water quenching is a drastic treatment and the curves of Figure 4 are used to exaggerate the influence of columbium. Under less severe conditions of treatment the effect of columbium additions is quite as beneficial. Table 5 lists the analyses of the steels in Figure 4.

Columbium is reported to be more efficacious than titanium in retaining the impact strength and toughness of 5-percent-chromium steel at low temperatures. Throughout a wide range of temperatures such as might be encountered in welded fabrication the influence of columbium brings about the retention of low-temperature impact strength. At temperatures as low as —40° F. the impact values are quite satisfactory as shown in Figure 5. Table 6 lists the analyses of these steels. Columbium makes the steel able to withstand all normal fabrication operations without developing any hard or brittle areas in the event that the steel is cooled too rapidly. At least one case is on record where tubes were heated quite hot for bending and immediately cooled with a water spray after forming. Now such practice is downright carelessness for an air-hardening material. But had columbium been incorporated in the analysis the operation could have been successful. Nor will any danger be encountered in low-temperature cleaning of columbium-bearing tubes. In addition columbium enhances the oxidation resistance of the tubes. And columbium improves resistance to creep.

Notwithstanding all the improvements conferred upon the 5-percent-chromium steels by the additions of columbium the prime reason for adding this element is the reduction of air-hardening tendencies during welding. Where suitable means are at hand for the preheating and annealing of these chromium alloys, welds in non-columbium alloys may be accomplished. The risk of cracks is always present though.

Not only to each other but also to mild steel are the low-chromium materials welded. Depending upon the

TABLE 5
Analyses of Steels in Figure 4

STEEL	% Cr.	% C	% Mo.	% W	% Cb
A	5.94	0.08	....	....	....
B	5.54	0.06	0.51	....	....
C	5.46	0.06	....	....	0.53
D	5.85	0.07	0.54	....	0.49
E	5.88	0.07	....	0.70	....
F	6.09	0.06	....	0.82	0.56

TABLE 6
Analyses of Steels in Figure 5

STEEL	% Cr	% C	% Mo	% Ti	% Cb
A	5.48	0.05	....	....	....
B	5.62	0.06	0.50	....	....
C	6.06	0.08	....	0.42	....
D	5.56	0.07	0.54	0.28	....
E	5.52	0.08	....	....	0.53
F	5.49	0.06	0.50	....	0.54

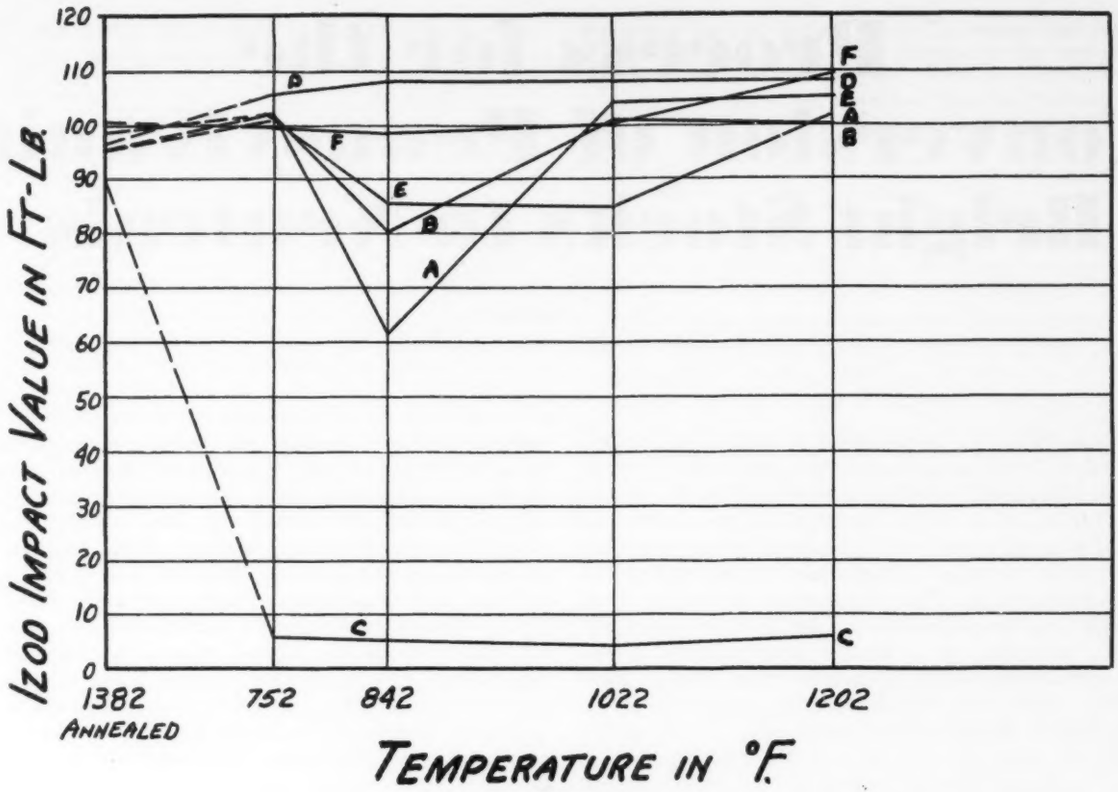


FIGURE 5

Impact strength of different 4-6 percent chromium alloys at —40° F. after holding for 700 hours at indicated temperatures.

design mild-steel electrodes, 5 percent chromium electrodes or austenitic stainless steel electrodes of either the 18-8 or the 24-12 variety may be used. The mild-steel electrodes are diluted to less than 2 percent chromium which materially reduces their air-hardening tendencies. The 5 percent chromium electrodes provide less dilution in the welded joint. And the austenitic types lead to less air-hardening and provide a joint with excellent resistance to corrosion.

The most common applications of 5 percent chromium steel to mild steel come about in lining towers where

[*Continued on Page 61*]

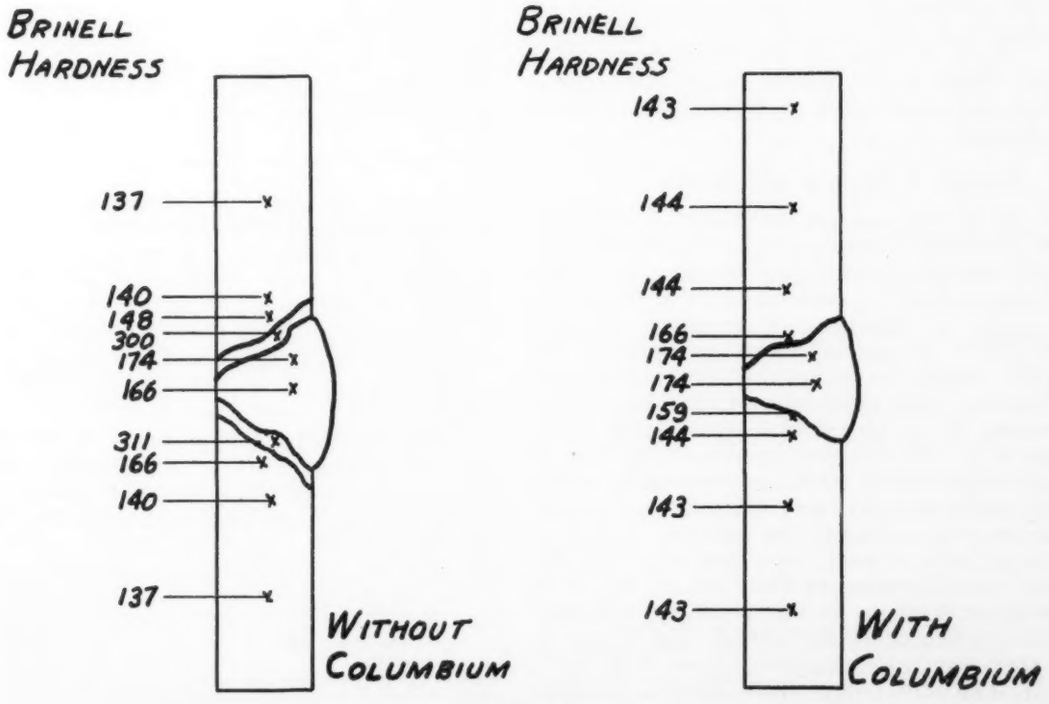


FIGURE 6

Effect of columbium on hardness of heat effected weld zone.

Process for the Conversion of Pennsylvania Bright Stocks to Neutrals*

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FOR some few years the trend in automotive lubrication practice has been toward progressively lighter, i.e., lower viscosity, lubricants, arousing an increased demand for neutrals and a correspondingly decreased demand for bright stocks for blending purposes. This situation is of peculiar significance to the refiner of Pennsylvania crudes. The proportion of bright stock to neutral in Pennsylvania crude is approximately 60 to 40, whereas, as a rough approximation, the average automotive lube oil requirement today could be met by a blend of just the reverse proportion, i.e., 40 parts bright stock to 60 parts neutral. Lube stocks of whatever viscosity are by far the most valuable products obtainable from the limited available supply of Pennsylvania crude. Consequently, the Pennsylvania refiner is forced by economic necessity to refine for maximum yield of both bright stock and neutrals —it is not possible to follow the practice, common in the Mid-Continent field, of obtaining extra slop-wax distillate (neutral stock) by running crude to a fuel-oil or cracking-stock residuum.

The continual forcing of Pennsylvania bright stock onto a market limited in demand to the available supply of Pennsylvania neutral has resulted in a marked decline in the price of bright stock as compared to the neutral. In the winter the balance of demand shifts even further towards the neutrals and there is a sharp increase in the differentials. This differential offers an attractive opportunity for a process for the conversion of lower-priced bright stock to neutral.

Details of Process and Yields

Fifteen pour bright stock is charged to a shell still. This is blended with 10 percent light oil such as kerosene. An alternative is to charge bright stock solution. Either procedure is satisfactory, the choice depending largely on whether it is desired to convert bright stock from storage or current production. The advantage of processing solution lies in the elimination of blending with light oil and the heat saving due to heating the bright stock only once. The still is brought up to temperature rapidly in the case of processing bright stock and conventionally when processing solution until the solution is denuded. Liberal steam is introduced. The overhead stream is cut first to naphtha storage, then gas oil and, when the stream viscosity reaches 35-40 vis at 100, it is cut to 180 stock storage. At this point the still temperature is approximately 525-550° F. The supply of steam is then cut back sharply and rapid firing is maintained. The still temperature reaches approximately 620° F. quickly and the viscosity of the overhead is 90-100 at 100. Steam and firing are then controlled to maintain the viscosity of the stream between 90 and 120 at 100° F. The operation is continued until about 93-96 percent of the original bright stock charge is taken overhead. The still temperature at this time has risen to approximately 700-720° F. The average cycle time from charge to charge will run about 60 hours. The bottoms can be segregated until enough is accumulated and then mixed with a light oil and reprocessed in a similar manner to the original bright stock conversion operation for the production of additional 180 stock or it can be put to fuel oil.

Yield and Recovery

Yields in this operation on the basis of bright stock charged are as follows:

180 Stock	95.0 percent
Bottoms	4.0 percent
Loss	1.0 percent

Quality of Products

	180 Stock	Bottoms
Gravity	32.0–32.5	16–17
Flash	110–115	660–680
Fire	140–150	735–745
Viscosity 100	95–105	.....
at 210	.....	720–760
Pour	20–25	40–45
Color	7–7+	+8 DDD

The 180 stock is then blended with normal Pennsylvania pressed oil or 85 stock or both. The proportion of each component is more or less immaterial although it is preferable not to use more than 30 percent of 180 stock from bright stock conversion in the mix. The blend is then reduced in the normal manner for reducing pressed oil to 180 distillate.

Ultimate yields on the basis of 180 stock from bright stock converted are as follows:

180 distillate .....112 percent

The 112 percent recovery is due to the ability of the process to absorb heavy ends of gas oil.

The 180 distillate produced from the mix reduced has the following specifications:

Gravity	30.0–30.5
Flash	415–425
Fire	460–480
Viscosity at 100	180–185
Pour	25–30
Color	5+–6+ NPA

The 180 distillate is finished off by conventional treatment to the desired finished 180 neutral color.

* Before meetings of the Department of Manufacture, National Petroleum Association, Bradford, December 11, 1940, Oil City, December 12, 1940; Butler, December 13, 1940.

Overall Yields 180 Neutral from Bright Stock

180 neutral	100.0 percent
*Fuel oil	3.9 percent
Loss	2.0 percent
	105.9 percent

* Assuming the bottoms are not reprocessed for additional 180 neutral.

Costs and Economics

The outstanding advantages of the process are two in number. In the first place it calls for absolutely no investment outlay in new equipment. Adequate shell still capacity is available at all Pennsylvania refineries. Further, the technique of operation and control is extremely simple, and to a considerable degree flexible, permitting complete mastery by the average stillman after brief instruction. In the absence of investment charge the refiner can easily afford to start and stop the operation on short notice, sensitive to slight changes in the market for bright stocks and neutrals making the process operation more or less profitable. All products and by-products of the operation are normal refinery products—no new refinery marketing problem is introduced.

The second advantage of this process lies in the fact that relatively large proportions of non-viscous neutral are carried into valuable 180 neutral oil instead of being sold as gas oil or non-viscous neutral. The reason for this lies in the relatively high viscosity of the bright stock distillate produced in the cracking of bright stock. As will be observed, this distillate contains from 10 to 15 percent of gas oil and lighter materials. On redistillation either in a rerun tube still or in the old-fashioned shell still rerun operation these light fractions are replaced by the heavier parts of the non-viscous neutral fraction blended with the bright stock distillate before rerunning. It is due to this phenomenon that the refiner is able to secure yields of approximately 100 gallons of 180 viscous neutral per 100 gallons of bright stock charged to the cracking operation.

The overall operating cost per gallon of 180 neutral from bright stock is $ .0325 per gallon. This includes extra filtering cost due to the 180 distillate being darker than normal 180 distillate and the extra cost involved because of the higher pour material produced.

Details are as follows:

Basis 1 Barrel Bright Stock Charged

Extra Paraflow for pour adjustment	$ .3150
Converting bright stock	.2100
Reducing 180 stock	.1021
Treating and finishing	.7371
Total	$1.3642
Operating cost per gallon 180 produced	.0325

The actual profit to be made by converting bright stock to 180 neutral is of course subject to the differential between the value of bright stock and the value of 180 neutral. This differential is also affected by the market value of the gas oil and fuel oil produced in the process. The following formula can be used to determine the cost of 180 neutral produced by this process for any value of bright stock, gas oil and fuel oil.

$$\text{Cost/gal. neutral} = \$\ .0325 + \text{value bright stock} + .059 \text{ value gas oil} - .039 \text{ value fuel oil}$$

Market value used in above formula is market value per gallon.

Operating Cost of Bright Stock Conversion (all figures are per barrel of bright stock charged to the operation)

	Cracking	Reduction	Finishing	Paraflow	Total
Labor	$ .0162	$ .0167	$ .0360	.....	$ .0689
Steam	.0902	.0090	.0135	.....	.1127
Fuel	.0620	.0231	.....	.....	.0851
Paraflow	.....	.....	.....	$ .3150	.3150
Miscellaneous	.0416	.0533	.0720	.....	.1669
Clay	.....	.....	.6156	.....	.6156
Total	$ .2100	$ .1021	$ .7371	$ .3150	$1.3642

Miscellaneous item includes minor utilities, maintenance and overhead costs; therefore this summary includes both fixed and variable costs.

Labor is estimated according to average experience for shell and tube stills for nine months of 1940. No additional labor was necessary for this operation.

Fuel is based on a cost per gallon of fuel of .02137.

The Refiners' Alloy

[*Continued from page 59*]

mild corrosion is a disturbing factor as well as in the attachment of trays and bubble caps. The selection of columbium-bearing steel forestalls the expensive heat treatment necessary where this material is not used. Generally this choice is economically sound.

In addition there are pressure units that cannot be annealed after welding. Here is another fine place to put the columbium-bearing alloy to work. And Figure 6 shows a welded joint in ½-inch plate where the combination of columbium-bearing 5-percent-chromium steel and 24-12 welding electrodes combined to eliminate any hard heat-affected zone whatsoever. Ordinary molybdenum bearing 4- to 6-percent-chromium steel welded with the same electrode showed a Brinell hardness of 300 and 311, respectively, on either side of the weld. This compares unfavorably with the 166 and 174 of the weld metal and the 137 of the plate material. Meanwhile the same steel with columbium added showed no zone higher than the 174 of the weld which gradually became lower until the 143 of the plate material was reached. Had an electrode of the 5-percent-chromium type been used the hardened zone of the metal without columbium would have been even harder.

Because of its development in the refineries, the 5-percent-chromium steel may rightfully be called the refiners' alloy. The many fine properties exhibited by the material make it well adapted to many problems encountered in modern refining practice. And the establishment of this excellent material of moderate cost by the petroleum industries has made it available to other industries like the chemical and power plants where similar services are found. Welding is at best a somewhat ticklish operation demanding alloying or special heat considerations that may best be afforded by experienced fabricators. At the same time much successful welding has been done by the refiners themselves when particular attention was given the several variables to be overcome.

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Elements of Vaporization and Condensation

Part X

Fractionation of Multi-Component Mixtures and Application of McCabe-Thiele Diagram to Complex Mixtures

R. L. HUNTINGTON, University of Oklahoma

A HIGH percentage of the fractionators in the petroleum industry process mixtures of hydrocarbons which contain three or more compounds. The calculation of the number of theoretical trays required for the processing of these more complex mixtures cannot be carried out rigorously by means of the McCabe - Thiele [16 18] binary component diagram. Through the selection, however, of two key components in a complex mixture a fair approximation can be made of the plate requirements for a fractionating tower by this simple two component diagram. In this analysis[10], the author has taken the fraction of a gasoline boiling in the kerosene range as the less volatile component of the binary mixture, and the gasoline fraction of the kerosene as the more volatile component. By applying this method to the performance of a 3 foot x 90 foot bubble-plate tower, it was found that the fractionation efficiency in the ten-plate gasoline-kerosene section was 90 percent of the theoretical.

In the case of a four component mixture such as:

	mol %
Propane	25
N. Butane	25
N. Pentane	25
N. Hexane	25

two key components such as normal butane and normal pentane might be selected if the propane and normal butane are to be taken off overhead, since the propane would have very little tendency to go to the bottom of the tower and vice-versa for normal hexane. In other words this real "hammering" process would call for the elimination of normal pentane from the overhead and normal butane from the bottoms.

In the same way, a three-component mixture might be handled through the selection of two hydrocarbons as key components, such as

	mol %
Propane	33⅓
N. Butane	33⅓
N. Pentane	33⅓

the key components being propane and normal butane if propane is to be the overhead product.

Calculations by the algebra route are rather tedious, since each theoretical tray requires an equilibrium determination between the vapor and liquid as well as a material balance around the tray for the composition of the vapor rising from the next tray below. A better understanding of the details of this method can be obtained by going through the actual slide-rule operations.

A mixture of hydrocarbons consisting of an equal number of mols each of propane, normal butane and normal pentane is to be fractionated in a well insulated column. A natural gasoline having a composition of (40 mol percent N. butane and 60 mol percent N. pentane) is desired, however, it is realized that a small amount of propane will be left in the bottoms. It is therefore assumed that the composition of the bottoms will be:

	mol %
Propane	0.50
Normal Butane	39.50
Normal Pentane	60.00

Likewise it is reasonable to assume that 0.5 mol percent of pentane will be left in the overhead product. A material balance for normal pentane on the basis of 100 mols of feed may now be made:

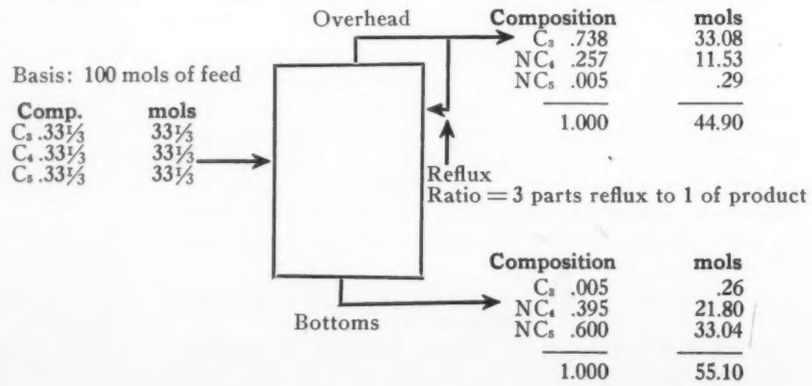
Basis 100 mols of Feed

	Feed	= Overhead Product	+ Bottoms
Pentane	.333(100) =	.005(V)	+ .60(100 — V)
	33.33 =	.005 V	+ 60 — .60V
	—26.67 =	—.595 V	

V = 44.9 (overhead product) in mols.

100 — V = 55.1 (bottoms) in mols.

The overall balance for the column may be shown:



If water is to be used for the condensation of the overhead product, it is assumed that the condensate will leave the water cooled exchanger at 100° F. Neglecting friction loss through the vapor line the pressure in the top of the tower will be equivalent to the vapor pressure of the condensate, which is calculated from Raoult's law as follows:

	mol frac.		Vapor Pressure		Partial Pressure lbs. per sq. in. abs.
C_3	.738	×	188	=	139.00
NC_4	.257	×	53	=	13.60
NC_5	.005	×	16	=	.08
			(Total Vapor Pressure)		152.68

Plate-to-Plate Calculations Based on Vapor Pressure Data

The next step is to determine the composition and temperature of the liquid on the top tray of the tower. This calls for an equilibrium calculation involving the trial and error method. A temperature of 120° F. is assumed as a first approximation since the liquid on the tray must be warmer than that of the overhead condensate in order to drive the vapor in that direction.

Based on Raoult's law, the liquid composition is calculated, and if the sum of its component fractions equals unity, the correct temperature has been selected. The calculation is as follows:

1st Trial—120° F.

Total Pressure π	×	mol. Fr. in Vapor y	=	Vapor Pressure p	×	mol. Fr. in liquid x
C_3—152.68		.738	=	245		.461
C_4—152.68		.257	=	72.5		.542
C_5—152.68		.005	=	22.5		.034
						1.037

2nd Trial—Assume Temperature of top tray = 125° F.

π	y	=	p	x
C_3—152.68	.738	=	256.0	.440
C_4—152.68	.257	=	78.0	.502
C_5—152.68	.005	=	24.5	.031
				.973

By interpolation, it is seen that 122° F. would be the approximate temperature, and the approximate composition of the liquid on the top tray:

C_3 = .449 (mol. fraction)
C_4 = .519 (mol. fraction)
C_5 = .032 (mol. fraction)
1.000

The composition of the vapor rising into the top tray is obtained through a material balance. If a reflux ratio of three parts of liquid reflux to one of overhead products is chosen for the operation of the tower, the balance around the top tray will be: (on basis 1 mol. of overhead product)

Streams leaving tray			=	Streams entering tray		
	Vapor from tray	+ Liquid overflow downward	=	Vapor rising into tray	+ Liquid refluxed from condenser	
C_3	4 mols (.738)	+ 3 mols (.449)	=	4 (y_3)	+ 3 (.738)	
C_4	4 mols (.257)	+ 3 mols (.519)	=	4 (y_4)	+ 3 (.257)	
C_5	4 mols (.005)	+ 3 mols (.032)	=	4 (y_5)	+ 3 (.005)	

By solving any two of the three above equations, the composition of the vapor from Tray number 2 can be determined.

$$C_3 \quad y_3 = \frac{.738 + (.449)3}{4} = .520$$

$$C_4 \quad y_4 = \frac{.257 + (.519)3}{4} = .455$$

$$C_5 \quad y_5 = \frac{.005 + (.032)3}{4} = .025$$

1.000

Vapor rising from tray number 2.

Liquid on tray No. 2

The temperature on tray No. 2 is first assumed to be 140° F.

1st Trial	π		y	=	p	x
C_3	152.68	×	.520	=	307	.259
C_4	152.68	×	.455	=	95	.733
C_5	152.68	×	.025	=	32	.120
						1.112

Assume Temperature = 150° F.

2nd Trial	π		y	=	p	x
C_3	152.68	×	.520	=	340	.234
C_4	152.68	×	.455	=	110	.630
C_5	152.68	×	.025	=	37	.103
						.967

Assume Temperature = 148° F.

3rd Trial	π		y	=	p	x
C_3	152.68	×	.520	=	330	.240
C_4	152.68	×	.455	=	106	.651
C_5	152.68	×	.025	=	35	.109
						1.004

Material balance around plate No. 2.

mols.

C_3	4 (.520)	+	3 (.240)	=	$4y_3$	+ 3 (.449)
C_4	4 (.455)	+	3 (.651)	=	$4y_4$	+ 3 (.519)
C_5	4 (.025)	+	3 (.109)	=	$4y_5$	+ 3 (.032)

y_3 = .363
y_4 = .555
y_5 = .082
1.000

Liquid on Tray No. 3

Assume a temperature of 170° F.

π		γ	=	ρ	x
152.68	×	.363	=	415	.1335
152.68	×	.555	=	145	.5840
152.68	×	.082	=	49	.2550
					.9725

Try temperature of 165° F.

152.68	×	.363	=	390	.1420
152.68	×	.555	=	130	.6520
152.68	×	.082	=	45	.2780
					1.0720

Temperature = 168° F.

Composition: C_3 = .1359, C_4 = .6028, C_5 = .2613 } Liquid on tray No. 3.
1.0000

Material balance around plate No. 3.

C_3	4 (.363)	+	3 (.1359)	=	$4y_3$	+ 3 (.240)
C_4	4 (.555)	+	3 (.6028)	=	$4y_4$	+ 3 (.655)
C_5	4 (.082)	+	3 (.2613)	=	$4y_5$	+ 3 (.109)

y_3 = .285
y_4 = .516
y_5 = .199 } Vapor from tray No. 4
1.000

Liquid on Tray No. 4

Assume a temperature of 185° F.

						x
C_3	152.68	×	.285	=	480	.0902
C_4	152.68	×	.516	=	168	.4680
C_5	152.68	×	.199	=	62	.4900
						1.0482

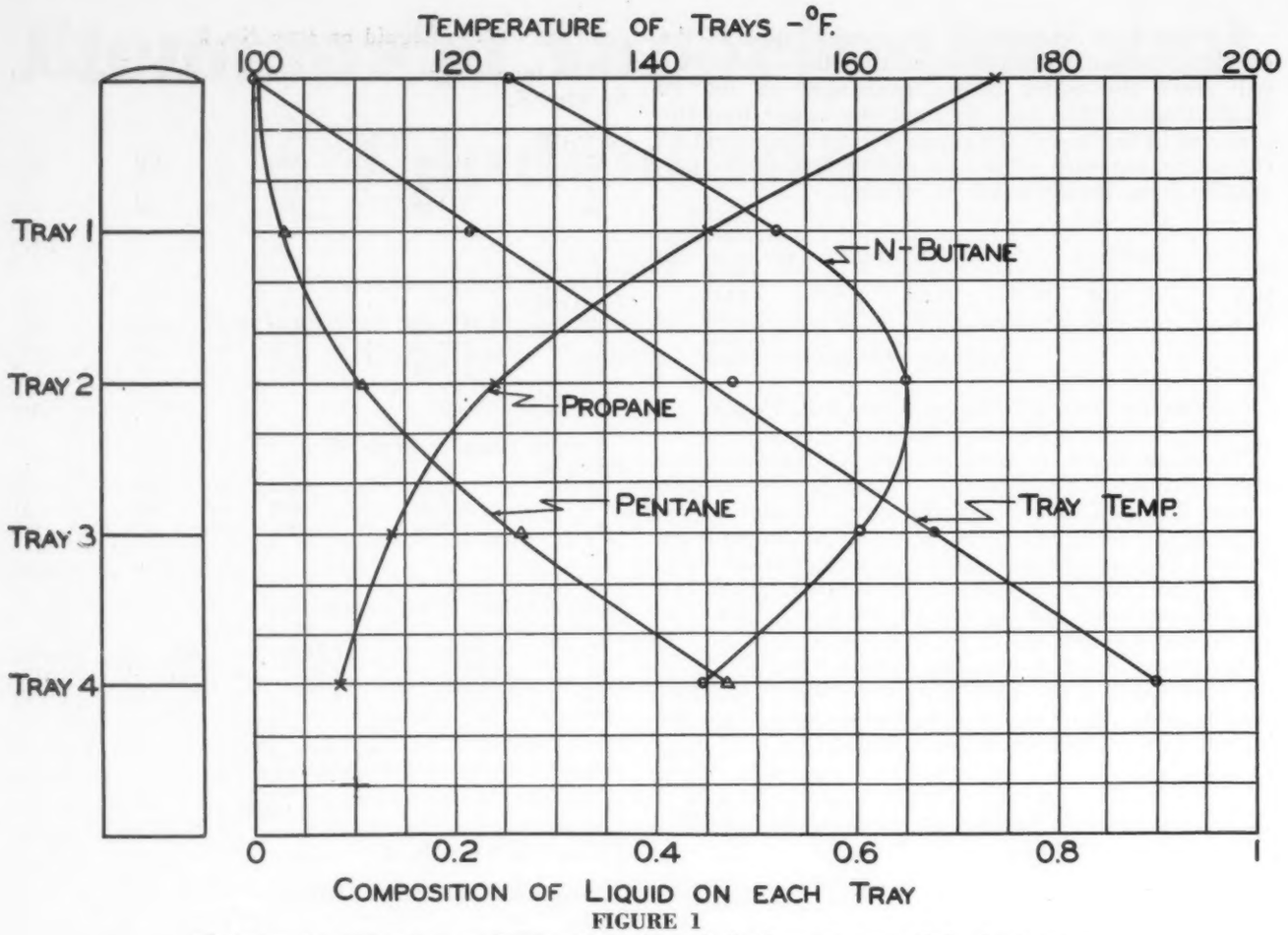


FIGURE 1

Variations in temperature and composition through the four top trays of the fractionator

Assume a temperature of 190° F.

					x
C_3	152.68	×	.285	= 505	.0850
C_4	152.68	×	.516	= 177	.4450
C_5	152.68	×	.199	= 65	.4700
					1.0000

These plate-to-plate calculations are shown graphically in Figure 1.

Application of "K" Charts

These equilibrium calculations can be made by use of the "K" charts[5] which are probably more nearly accurate than the vapor pressure chart, since the "K" values are based on experimental data. In the above equilibrium calculation, a temperature of 190° F. is assumed: Pressure = 152.68 pounds.

Y	=	K	X	$\frac{p}{\pi}$
.285	=	2.25	.1265	3.300
.516	=	.110	.4700	1.160
.199	=	.51	.3900	.427

According to the "K" charts the volatility of propane is less than the vapor pressure chart value and that of pentane greater than the vapor pressure reading.

Plate-to-Plate Calculations based on "K" Values

Liquid on Top Tray No. 1 Assume a temperature of 125° F.

	y	=	K x or	x
C_3	.738	=	1.42 x_3	.519
C_4	.257	=	.56 x_4	.458
C_5	.005	=	.22 x_5	.023
				1.000

A material balance around the top tray No. 1 is then made in order to get the composition of the vapor rising from tray No. 2.

	Vapor from 1		Liquid from 1		Vapor to 1 tray		Liquid to 1 tray
C_3	4 (.738)	+	3 (.519)	=	$4y_3$	+	3 (.738)
C_4	4 (.257)	+	3 (.458)	=	$4y_4$	+	3 (.257)
C_5	4 (.005)	+	3 (.023)	=	$4y_5$	+	3 (.005)

$y_3 = .5740$
$y_4 = .4075$
$y_5 = .0185$
1.0000
} Vapor from tray No. 2

Liquid on Tray No. 2. Assume Temperature = 150° F.
First Trial

y	=	Kx				
.5740	=	1.75 x_3	x_3	=	.328
.4075	=	.77 x_4	x_4	=	.530
.0185	=	.32 x_5	x_5	=	.058
					.916

Liquid on Tray No. 2. Assume Temperature = 140° F.
Second Trial

.5740	=	1.55 x_3	x_3	=	.370
.4075	=	0.70 x_4	x_4	=	.582
.0185	=	0.28 x_5	x_5	=	.066
					1.018

Therefore the temperature of plate 2 = 142° F. and the liquid:

$C_3 = .363$
$C_4 = .572$
$C_5 = .065$
1.000
} Liquid on tray No. 2

A material around tray 2.

	From Tray				To Tray		
C_3	4 (.5740)	+	3 (.363)	=	$4y_3$	+	3 (.519)
C_4	4 (.4075)	+	3 (.572)	=	$4y_4$	+	3 (.458)
C_5	4 (.0185)	+	3 (.065)	=	$4y_5$	+	3 (.023)

$y_3 = .4820$
$y_4 = .4930$ } Vapor from Tray No. 3.
$y_5 = .0250$

Liquid on Tray No. 3. Assume 160° F. for first trial.

	y	=	Kx			=	
C_3	.482	=	1.90	x_3	x_3	=	.253
C_4	.493	=	.85	x_4	x_4	=	.581
C_5	.025	=	.36	x_5	x_5	=	.069
							.903

Liquid on Tray 3, assume a temperature = 150° F. Second trial.

	y	=	Kx			=	
C_3	.482	=	1.75	x_3	x_3	=	.275
C_4	.493	=	.77	x_4	x_4	=	.640
C_5	.025	=	.32	x_5	x_5	=	.078
							.993

Temperature = 149° F. Liquid $x_3 = .277$
$x_4 = .645$ } Liquid on tray 3.
$x_5 = .078$

Material balance around tray 3.

	From Tray				To Tray		
	Vapor		Reflux		Vapor		Reflux
C_3 =	4 (.482)	+	3 (.277)	=	$4y_3$	+	3 (.363)
	4 (.493)	+	3 (.645)	=	$4y_4$	+	3 (.572)
	4 (.025)	+	3 (.078)	=	$4y_5$	+	3 (.065)

$y_3 = .418$
$y_4 = .548$ } Vapor from Tray No. 4.
$y_5 = .044$

Liquid on tray 4. Assume Temperature = 160° F.

y	=	Kx			=	
.418	=	1.90	x_3	x_3	=	.220
.548	=	.85	x_4	x_4	=	.643
.044	=	.36	x_5	x_5	=	.122
						.985

Temperature = 158° F. on tray 4.

Composition of Liquid

$\times_3 = .221$
$\times_4 = .647$ } Liquid on tray 4.
$\times_5 = .122$

Material balance around tray 4.

	From				To		
4 (.418)	+	3 (.221)	=	$4y_3$	+	3 (.277)
4 (.548)	+	3 (.647)	=	$4y_4$	+	3 (.645)
4 (.044)	+	3 (.122)	=	$4y_5$	+	3 (.078)

$y_3 = .376$
$y_4 = .550$ } Vapor from tray 5.
$y_5 = .074$
1.000

Liquid on tray 5. Assume a Temperature = 170° F.

y	=	Kx			=	
.376	=	2.05	x_3	x_3	=	.183
.550	=	.93	x_4	x_4	=	.592
.074	=	.40	x_5	x_5	=	.184
						.959

Liquid on tray 5. Assume a temperature = 165° F.

.376	= 1.98	x_3	x_3	= .190	
.550	= .89	x_4	x_4	= .616	} Liquid on Tray No. 5
.074	= .38	x_5	x_5	= .194	
				1.000	

The temperature at the base of the tower can be determined by trial and error. Assume a temperature of 200° F.

y	=	Kx		
y_3	=	2.40 (.005)	y_3	= .012
y_4	=	1.20 (.395)	y_4	= .474
y_5	=	.57 (.600)	y_5	= .326
				.812

Second trial—assume a temperature of 220° F. for the base.

$y_3 = 2.60$ (.005) $y_3 = .013$
$y_4 = 1.40$ (.395) $y_4 = .555$ } Vapor from Bottom Product
$y_5 = .69$ (.600) $y_5 = .414$
.982

Approximate temperature of base of tower = 222° F.

From these two sets of calculations, it is easily seen that conditions or limitations were fixed upon the tower in the way of reflux ratio, and overhead product which makes it possible to obtain a composition approximating that of the incoming feed.

The writer has submitted the problem to a class of 15 chemical engineering students, assigning a different set of conditions for each member of the class, with the result that several solutions were obtained that finally gave compositions comparable to the feed. The set of conditions which netted the closest approximation to feed composition called for an overhead product of 2.0 mol percent normal pentane and a bottoms of 39.5 percent normal butane and 58.5 percent normal pentance, with a reflux ratio of 4 parts of reflux to 1 of product.

From the foregoing calculations, it is readily seen that an exact solution of the theoretical tray requirements for as simple a mixture as three components is like "hunting for a needle in a hay stack," so numerous are the combinations of overhead and bottom products and reflux ratios only one which will fit into the "groove."

Many simplifying methods (see literature cited) have been offered as a basis for fractionator design. Experience has also been a big contributor in design progress since nothing is as sure as the trial and error method although it is often an expensive route to follow. Oftentimes, however, the elementary empirical method of attacking the problem is the only one to pursue. Indeed the petroleum refining industry has built itself up largely through this rough and tumble fashion. Narrowing margins of profit, however, call for the application of engineering principles by the surer method, the scientific approach.

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Equilibria in Reactions Of Hydrocarbons

XII. Calculation of Equilibria in Isomerization Of Butenes and Butanes*

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CONCLUSIONS

1—Comparing the equilibrium constants of isomerization of butenes and butanes calculated by means of spectroscopical data with experimental data the inexactness of the heats of formation of butanes from the elements was shown on which the calculation is based.

2—It was shown that a decrease of the heat of isomerization of butane to isobutane to $\Delta H_{298.1} = -2270 \pm 200$ cals./mole makes it possible to prevent the discrepancy between the data obtained by spectroscopical calculations and experimental data.

IN THE previous articles of this series Zharkova[1] showed that equilibria in hydrogenation of ethylene, propene and butenes can be calculated from the free energies of formation of these hydrocarbons obtained by Pitzer[2] from spectroscopical values and that the results of these calculations are in good agreement with experimental data given by a number of authors. Because of this an attempt was made by the present writer to use Pitzer's data for calculation of equilibria in isomerization of butenes and butanes. It is shown below that the equilibria in isomerization of butenes without branching of the chains calculated according to Pitzer

$$\alpha\text{-}C_4H_8 \longleftrightarrow \beta\text{ cis-}C_4H_8,$$
$$\alpha\text{-}C_4H_8 \longleftrightarrow \beta\text{ trans-}C_4H_8$$
$$\beta\text{ cis-}C_4H_8 \longleftrightarrow \beta\text{ trans-}C_4H_8$$

well agrees with experimental data for these equilibria as reported by Frey and Huppke[3] and Kistiakowsky and Smith[5]. However, for the cases of equilibria in reactions

$$\text{norm.-}C_4H_8\text{ (sum of isomers)} \longleftrightarrow \text{iso-}C_4H_8$$
$$\text{norm.-}C_4H_{10} \longleftrightarrow \text{iso-}C_4H_{10},$$

taking place with branching of the carbon skeletons Pitzer's data show a poor agreement with the experimental data obtained by Serebryakova and Frost,[4] Moldavskii and Nizovkina[6] and Montgomery et al.[8]

The object of the present study consisted in determination of the causes of the deviations observed upon comparing the data calculated by Pitzer with experimental data.

Pitzer used for the calculation of thermodynamical values the spectroscopical data for frequencies of vibration in hydrocarbon molecules. The values of the moment of inertia necessary for the calculations and characterizing the rotation levels of the molecules were calculated from the sizes and the forms of the molecules of the hydrocarbons determined by electron diffraction and spectroscopical studies. Finally, the rotation of the groups CH_3, CH_2CH_3, etc. around the C = C axis was found by Pitzer to be a restricted rotation and the value of the potential barrier of the restricted rotations is determined by Pitzer more or less arbitrarily. For ethane and neopentane the value of the rotation restriction for the CH_3 group was so selected that the calculations satisfied the values determined on the basis of the third principle of Nernst. For isobutane and propane Pitzer determines this value by interpolation of the numbers for ethane and neopentane (tetramethylmethane). For α-butene and butane he assumed the rotation restriction of the CH_3 groups equal to that in propane. For the C_2H_5 groups in butane and rotation restriction was estimated more or less arbitrarily and the potential barrier of the restricted rotations of the CH_3 group in β-butene, around the central C = C in α-butene and CH_3 group in isobutene were so selected that they corresponded to the entropy calculated on the basis of the third law of Nernst and the data on the equilibrium in dehydrogenation of paraffins according to Frey and Huppke.[3] The heats of formation of saturated hydrocarbons from the elements required for the calculation were taken from the studies of Rossini[7, 9] and for the unsaturated hydrocarbons they were calculated from the data for the saturated hydrocarbons and the heats of hydrogenation of olefins at 355° K. determined by Kistiakowsky and co-workers.[11] For ethylene this calculation was completely confirmed by the value determined by Rossini[10] on the basis of the heat of combustion.

1. *Isomerization of Normal Butenes.* The changes of the thermodynamical potentials

$$\Delta\phi = \Delta S - \frac{\Delta H}{T} = -\frac{\Delta Z^*}{T} \qquad (1)$$

(*Pitzer denotes this value by ΔF)

*This translation is submitted by the Petroleum Division of the American Chemical Society which, however, assumes no responsibility for the facts and opinions presented in this paper, nor does it necessarily endorse statements made therein.

of formation of isomeric butenes with a straight chain from graphite and hydrogen under atmospheric pressure determined by Pitzer are given in Table 1. According to these data the constants are calculated for the conversion of α-butene to cis- and trans-β-butenes. The calculation is carried out by means of equations of the following type:

$$\Delta\phi\,\alpha \rightarrow \text{cis} = \Delta\phi_{\text{cis}} - \Delta\phi\,\alpha, \qquad (2)$$

$$\log K_{p\,\alpha \rightarrow \text{cis}} = \frac{\Delta\phi\,\alpha \rightarrow \text{cis}}{4.575^{**}} \qquad (3)$$

$$K_{p\,\alpha \rightarrow \text{cis}} = \frac{P_{\text{cis-}C_4H_8}}{P\,\alpha\text{-}C_4H_8} \qquad (4)$$

TABLE 1
Equilibrium in Isomerization of Straight Chain Butenes

	$\Delta\ \phi$			K_p		Composition of the Mixture, %		
t°K	α C_4H_8	β cis- C_4H_8	β trans- C_4H_8	$\alpha \rightarrow$ cis	d $\rightarrow$ trans	α	β -cis	β -trans
300....	—53.7	—49.7	—47.2	7.49	26.35	3	21	76
350....	—54.1	—51.0	—48.8	4.79	14.40	5	23	72
400....	—54.6	—52.1	—50.4	3.52	8.28	8	28	64
450....	—55.2	—53.2	—51.7	2.69	5.82	10	29	61
500....	—55.8	—54.2	—53.0	2.24	4.09	13	31	56
600....	—56.9	—56.0	—55.1	1.57	2.47	19	31	50
700....	—57.9	—57.6	—56.8	1.16	1.74	25	30	45
800....	—58.8	—58.8	—58.2	1.00	1.35	30	30	40
900....	—59.5	—59.9	—59.5	0.82	1.00	35.5	29	35.5
1000....	—60.1	—60.7	—60.4	0.74	0.86	39	28	33

The equilibrium constants were used for calculating the composition of the equilibrium mixture of straight-chain butenes. The content of isomers was determined using the following equations:

$$x\,\alpha = \frac{1}{1 + K_{p\,\alpha \rightarrow \text{cis}} + K_{p\,\alpha \rightarrow \text{trans}}};$$

$$x_{\text{cis}} = \frac{K_{p\,\alpha \rightarrow \text{cis}}}{1 + K_{p\,\alpha \rightarrow \text{cis}} + K_{p\,\alpha \rightarrow \text{trans}}}; \qquad (5)$$

$$x_{\text{trans}} = 1 - x_{\alpha} - x_{\text{cis}}.$$

The content of isomers is indicated in Table 1 in percent (100x). The calculated composition of the equilibrium mixture is compared in Figure 1 with experimental data of Frey and Huppke[8] and of Kistiakowsky and Smith.[5] Frey and Huppke determined the equilibrium composition of the mixture of butenes formed by dehydrogenation of normal butane. Kistiakowsky and Smith determined the equilibrium proportions in the mixture of cis- and trans-β-butenes reached in conversion of these substances. At 640-663° K. it was found that $P_{\text{trans}}/P_{\text{cis}} = 1.12$. In calculating the composition of the equilibrium mixture according to Kistiakowsky and Smith the content of α-butene in the mixture at 650° K. was taken to be 23 percent in accordance with the data of Table 1. Figure 1 shows that the discrepancy between the calculated and the experimental data is not systematic in character. It is within the limits of experimental error reaching 5-7 percent on the sum of percentages of all three isomers.

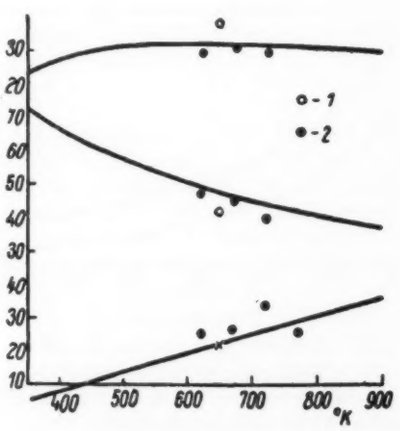

FIGURE 1
1—Kistiakowsky and Smith;
2—Frey and Huppke.

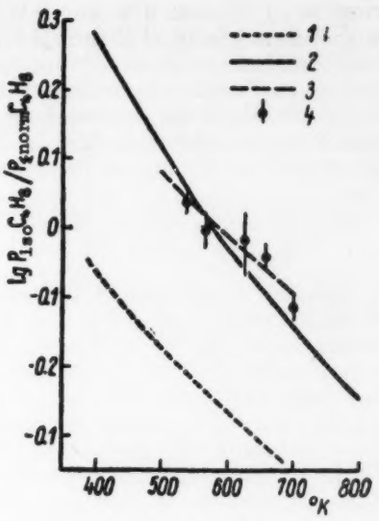

FIGURE 2
1—Pitzer; 2—Pitzer's Data, corrected;
3 — Equation /7/; 4 — Experimental.

TABLE 2
Equilibrium in Isomerization of Normal Butene to Isobutene

	According to Pitzer				/7/	Corrected Valves		
t°K	$\Delta\phi$iso	$\Delta\phi$norm.	$\Delta\phi$ iso	$\log \frac{\text{iso}}{\text{norm.}}$	$\log \frac{\text{iso}}{\text{norm.}}$	Correcn. to log K_p	$\log \frac{\text{iso}}{\text{norm.}}$	$\delta \log \frac{\text{iso}}{\text{norm.}}$ (exptl.-cortd.)
300	—46.1	—46.7	0.6	0.13	.....	0.47	0.60	.....
350	—48.0	—48.1	0.1	0.02	.....	0.40	0.42	.....
400	—49.8	—49.5	—0.3	—0.07	.....	0.35	0.28	.....
450	—51.3	—50.7	—0.6	—0.13	.....	0.31	0.18	.....
500	—52.6	—51.8	—0.8	—0.18	0.08	0.28	0.10	—0.02
600	—54.9	—53.7	—1.2	—0.26	—0.02	0.23	—0.03	+0.01
700	—56.7	—55.2	—1.6	—0.35	—0.10	0.20	—0.15	+0.05
800	—58.3	—56.4	—1.9	—0.42	.....	0.17	—0.25	.....
900	—59.6	—57.6	—2.0	—0.44	.....	0.16	—0.28	.....
1000	—60.5	—58.4	—2.1	—0.46	.....	0.14	—0.3	.....

****The third digit in this number (7) is illegible in the original—Trans.**

2. *Isomerization of Normal Butenes into Isobutene.* In order to calculate the equilibrium in isomerization of an equilibrium mixture of butenes to isobutene according to Pitzer it is necessary to find the change of the thermodynamic potentials in formation of the mixture from the elements $\Delta\phi\Sigma_{norm.}$ This operation can be carried out by means of the equation 6.

$$\Delta\phi\,\Sigma_{norm.} = R\ln[\exp(\Delta\phi_{\alpha}/R) + \exp(\Delta\phi_{cis}/R) + \exp(\Delta\phi_{trans}/R)]. \quad (6)$$

Use of this equation is equivalent to determination of the equilibrium constant of formation of the mixture of butenes from the elements by adding the equilibrium constants of formation of the individual isomers from their elements. The values of $\Delta\phi\Sigma_{norm.}$ calculated by this equation and the thermodynamical potentials for isobutene determined by Pitzer are given in Table 2. With the aid of these data the values $\Delta\phi\Sigma_{norm.\rightarrow iso}$ and $\log K_p = \log P_{iso\text{-}C_4H_8} P\Sigma_{norm.\text{-}C_4H_8}$ were determined by means of equations similar to equations 2 and 3.

Direct experimental measurements of the equilibrium constants of this reaction were carried out by Serebryakova and Frost[4] for temperatures of from 538 to 699° K. and resulted in the following equation connecting the equilibrium constant with the temperature

$$\log K_p = \frac{304}{T} - 0.528 \pm 0.02. \quad (7)$$

The data calculated by this equation are reported in Table 2. A comparison shows that the calculated values differ from the experimental by 0.24-0.26 units in the logarithm of the constant which corresponds to an error in the equilibrium constant of from 74 to 81 percent. It is shown in Figure 2 that individual experimental points differ to the same extent from points calculated according to Pitzer. The difference cannot be explained by experimental errors and is caused by deficiencies in Pitzer's calculations.

3. *Isomerization of Normal Butane to Isobutane.* The changes of the thermodynamical potential calculated by Pitzer for the formation of butanes from the elements and the logarithms of the equilibrium constants of isomerization of butane

$$K_{p\ norm.\rightarrow iso} = P_{iso\text{-}C_4H_{10}}/P_{norm.\text{-}C_4H_{10}}$$

calculated by the present writer in the above described way are given in Table 3. The logarithms of the equilibrium constants calculated according to Pizer are compared with the experimental data of Moldavskii and Nizovkina and of Montgomery et al in Figure 3. The data calculated according to Pitzer are indicated by the dotted line. In addition, Figure 3 shows the logarithms of the equilibrium constants calculated by Serebryakova and Frost from their measurements of the equilibria in isomerization of butenes (x) and the logarithms of the equilibrium constants for dehydrogenation of butanes found by Frey and Huppke, as well as values calculated by the present writer (+) from the data for isomerization of butenes given by Serebryakova and Frost and from the equilibrium constants for dehydrogenation of butanes determined from the thermodynamical values calculated by Pitzer. All these data occupy on the graph points located considerably higher than the curve of Pitzer, similarly to what was observed for the case of conversion of n-butenes to isobutene.

Moldavskii and Nizovkina gave for their data of isomerization of butanes the following equation

$$\log K_p = \log (P_{iso\ C_4H_{10}}/P_{norm\text{-}C_4H_{10}}) = \frac{611}{T} - 1.204 \quad (8)$$

The data calculated by means of this equation are shown in Table 3 and Figure 3 in the form of a broken line. A comparison of the data calculated by Pitzer with those calculated by equation 8 shows that the difference between the logarithms of the equilibrium constants sharply diminishes with the rise of the temperature while the value of this difference multiplied by the temperature, $T\,\delta \log K_p$ changes with change of the temperature much slower. (The inconstancy of $\delta \log K_p$ disproves the assumption of Kassel[12] that the deviation of the calculated

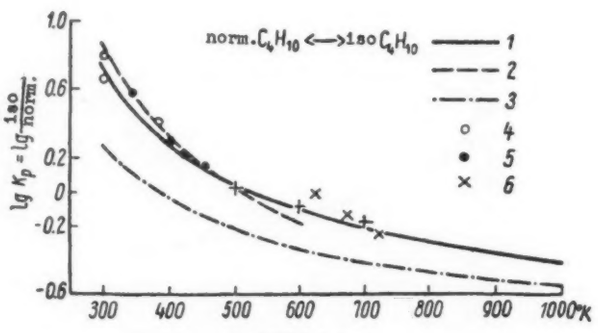

FIGURE 3

1—Pitzer, $\Delta E_0° = 2200$ cals./mole; 2—Moldavskii and Nizovkina, $\Delta H = 2800$ cals./mole; 3—Pitzer, $\Delta E_0° = 1550$ cals./mole; 4—Montgomery; 5—Moldavskii and Nizovkina; 6—Calculated by Frost and Serebryakova.

TABLE 3

Equilibrium in Isomerization of Normal Butane to Isobutane

t°K	According to Pitzer				/8/		Corrected Valves		
	$\Delta\phi$iso	$\Delta\phi$norm.	$\Delta\phi\varepsilon$norm.→iso	$\log \frac{iso}{norm.}$	$\log \frac{iso}{norm.}$	$T\delta\log \frac{iso}{norm.}$**	Correction to $\log K_p$	$\log \frac{iso}{norm.}$	$\delta \log K_p$ (exceptl.-cortd.)
300.....	16.4	15.2	1.2	0.26	(0.85)*	(177)*	0.47	0.73	(0.12)
350.....	0.9	0.5	0.4	0.09	0.54	157	0.40	0.49	0.05
400.....	—11.2	—10.9	—0.3	—0.07	0.32	156	0.35	0.28	0.04
450.....	—20.7	—20.0	—0.7	—0.15	0.15	135	0.31	0.16	—0.01
500.....	—28.4	—27.4	—1.0	—0.22	0.02	120	0.28	0.06	—0.04
600.....	—40.2	—38.7	—1.5	—0.33	(—0.19)	(84)	0.23	—0.10	(—0.09)
700.....	—49.0	—47.1	—1.9	—0.42	.....	.....	0.20	—0.22	.....
800.....	—55.7	—53.5	—2.2	—0.48			0.17	—0.81	.....
900.....	—61.0	—58.6	—2.4	—0.52	Mean Valve 140		0.16	—0.86	.....
1000.....	—65.1	—62.6	—2.5	—0.55			0.14	—0.41	.....

* The values given in parenthesis were obtained by extrapolation and were not used in the calculation of the mean value.

** $\delta \log K_p = \delta \log \frac{iso}{norm.} = \log \frac{iso}{norm.}$ /8/ $- \log \frac{iso}{norm.}$ (Pitzer)

values from the data of Montgomery et al is caused by the error in the assumed difference of the entropies of butanes. If this were correct, $\delta \log K_p$ should have been approximately constant. Furthermore, if Kassel's assumption were correct, the calculation, on the basis of the data of Pitzer and Kassel, of the equilibria for isomerization of normal butenes to isobutene should give results agreeing with the experimental results.) Since in the equations determining $\Delta\phi$ or $\log K_p$ all terms connected with some molecular constants, with the exception of the term the presence of which is due to the heat effect, show little dependence upon temperature, the discrepancy between the calculated and experimental values rapidly diminishing with the temperature, may serve as the basis for an assumption that the discrepancies observed in both cases (butenes and butanes) are caused by inaccuracies in the values of the heats of formation of normal butane and isobutane determined by Rossini[7] and used by Pitzer for the calculations.

On the basis of thermodynamical considerations indicating that the heat effect is present as a term in the expression $RT \ln K_p = T\Delta\phi = T\Delta S - \Delta H$ it is clear that $T \log K_p$ should show a linear dependence upon the heat effect. However, no great significance should be ascribed to the decrease, with rise of temperature, of the values of $T\ \delta \log K_p$ calculated by the present writer and given in Table 3, since this decrease is apparently caused by small errors in the measurements of Moldavskii and Nizovkina due to which the curve based on their data runs somewhat steeper than the true curve. This is confirmed by a comparison of the data of Moldavskii and Nizovkina with those of Montgomery et al, as shown in Figure 3. The data of the American authors are seen to be situated somewhat lower than the curve of Moldavskii and Nizovkina.

The values of $T\ \delta \log K_p$ given in Table 3 were used by Frost for correction of the calculation based on the thermodynamical values found by Pitzer. The average value of $T\ \delta \log K_p$ is 140 ± 20. This value corresponds to the error in the heat effect of isomerization of normal butane to isobutane, $\delta\Delta\ E°_o = -640 \pm 100$ cals./mole. To account for this error the values of the logarithm of the equilibrium constants of isomerization of butanes and butenes calculated with the aid of Pitzer's data should be increased by

$$\delta \log T = \frac{+140}{T} \qquad (9)$$

Tables 2 and 3 report the logarithms of the equilibrium constants of isomerization of normal compounds to iso-compounds calculated in this way. The corrected data are given as continuous curves in Figures 2 and 3. A comparison of the corrected data with experimental data indicates that the introduced correction eliminates almost entirely the difference between the calculated and the experimental values. For isomerization of normal butenes into isobutene the difference between the calculated result and that obtained by the empirical equation is reduced to 0.01-0.05 units in the logarithm of the constant (Table 2). Individual points approach calculated points within 0.05 (Figure 2).

For isomerization of butanes the corrected data deviate from the experimental data of Moldavskii and Nizovkina only in one case (70° C. = 343° K.) by about 0.1 units of the logarithm of the equilibrium constant; the points obtained at higher temperatures agree with the calculated within 0.05. The data of Montgomery and co-workers are located on both sides of the corrected curve at equal distances. (Montgomery and co-workers calculated the equilibrium constants in the liquid phase. The present writer recalculated the equilibrium constants for the gaseous phase assuming that the liquid mixture of butanes follows the law of Raoult.) The points obtained by recalculating the data for the equilibria of isomerization of butenes on the basis of the data of equilibria in dehydrogenation of butanes also show a satisfactory agreement with the corrected calculation.

All the above clearly indicates that the heats of formation of butanes on which Pitzer based his calculations are inexact. The heat of isomerization of normal butane to isobutane

$$\Delta H_{298.1} = -1630 \pm 150 \text{ cals./mole}$$

(according to Rossini[7] and in Pitzer's recalculation $\Delta E°_o = -1550$ cals./mole) should be diminished by 640 ± 100 cals./mole; thus, the heat of isomerization of normal butane to isobutane will be $\Delta H_{298.1} = -2270 \pm 200$ cals./mole.

Unfortunately, it is impossible to correct the value $\Delta\phi = -\Delta Z/T$ given by Pitzer for butenes and butanes, using the calculations of the present writer, since it is not known how the error in the heat of isomerization is to be distributed between the heats of formation of the normal butane and isobutane.

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[4] E. K. Serebryakova and A. V. Frost, Zhur. Obsh. Khim. (J. Gen. Chem.) **7**, 122, (1937); Foreign Literature Service Abstract 38A.
[5] G. B. Kistiakowsky, W. R. Smith, J. Am. Chem. Soc., **58**, 766, (1936).
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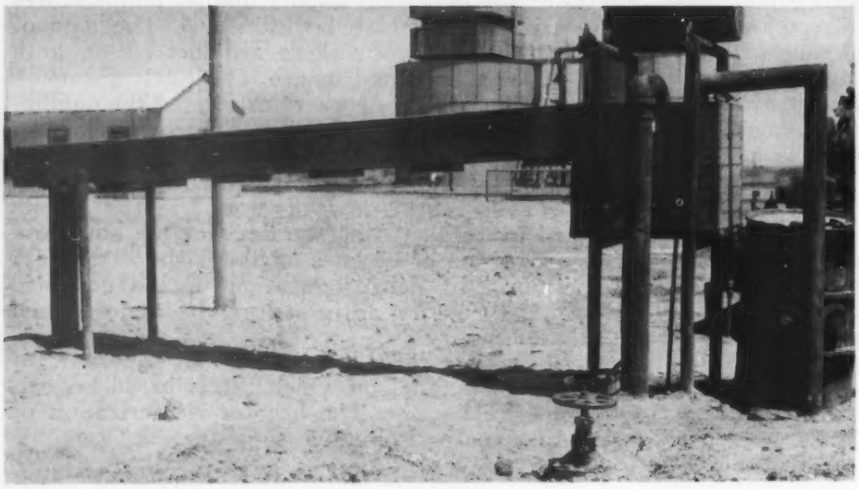
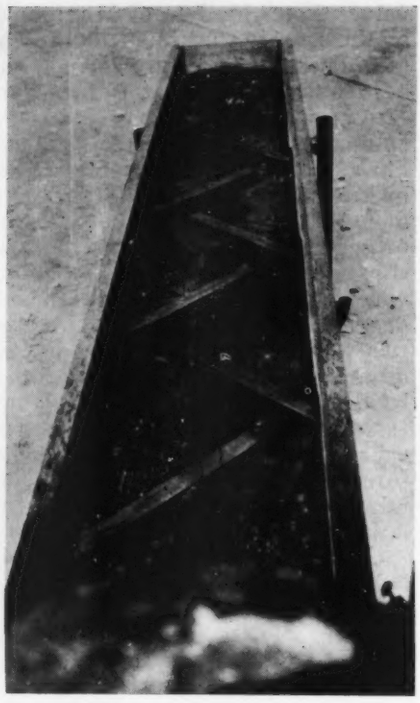
Acid Control of Scale In Cooling Water



Flume with pitch for gravity flow for introducing acid into cooling water



Staggered baffles assure proper mixing of acid and water.

IN order to modify the highly mineralized water produced in Eastern New Mexico so that scale will not be deposited on the outer surface of atmospheric coolers in its Eunice gasoline plant, Skelly Oil Company has built an acid-mixing device at a convenient point in yard where fresh make-up water flows to the cooling tower basin.

Sulphuric acid is stored in a horizontal combination storage vessel and blow case placed near the treating plant. From this the chemical is transferred to a small working vessel. The treating plant proper consists of a manual control acid-feeding needle valve, a working tank which contains sufficient acid for several hours use and a mixing flume fitted with staggered baffles. The frame-work for the unit consists of pipe, imbedded in concrete, supporting the entire apparatus, including the small acid-working vessel, the fresh water piping and the flume.

GRAVITY FLOW

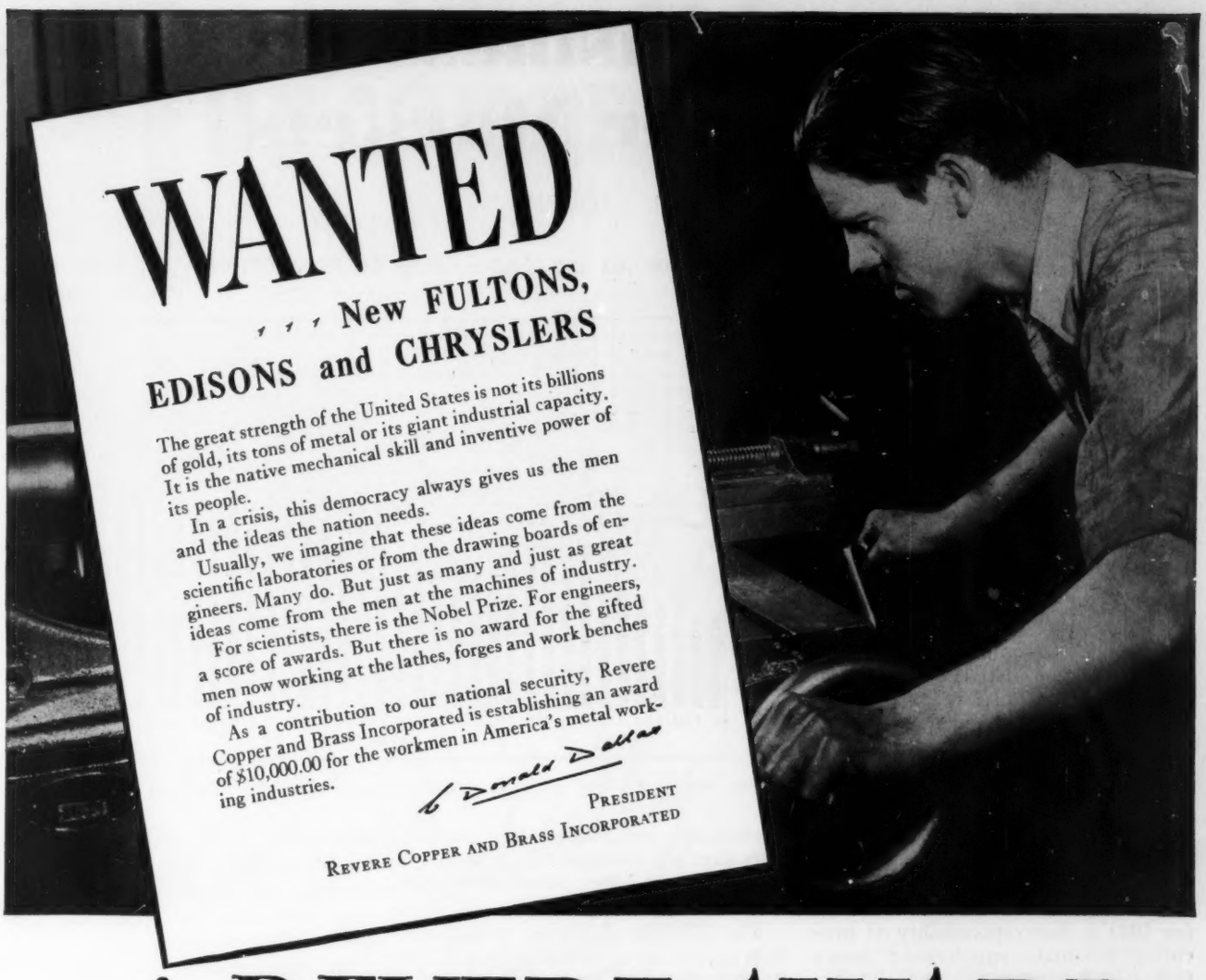
The flume is made of two-inch planking with a larger portion at the end at which the fresh water enters, approximately twice the depth of the flume itself. The remainder of the flume extends horizontally, with a slightly lowered outlet end, so the water will be forced to flow more rapidly and with greater turbulence than if the flume was laid on a level. The unit is high enough to force the water to flow readily through conductor piping to the cooling tower basin.

The water produced from the deep wells flows by gravity from a standpipe at the wells through two pipe lines, each fitted with control gates for regulating the volume of make-up, to the deeper section of the mixing flume, with nipples on the ends of the pipe looking downward to prevent splashing and increased turbulence prior to the addition of acid. The working tank sets directly above the deeper part of the flume, supported by extensions of the frame which carries the unit. The tank is made of heavy-gauge steel, laid horizontally and tacked to the supporting frame to prevent movement when filled or when acid is being mixed with the water. A pipe connected to the storage vessel permits recharging of the working tank by opening a control valve.

MANUAL ACID CONTROL

The flume is fitted with seven staggered baffles which create sufficient turbulence to thoroughly mix the acid with the water before the opposite end is reached. Acid is admitted to the water through the manual control attached to the lower side of the working tank, and the amount of acid is governed by the condition of the water, the volume treated and results desired. Tests conducted daily are the controlling factor in acid mixing, as the water in the outlet of the flume must be maintained slightly alkaline.

So that the concentration of solids will not exceed the required proportion in the cooling tower basin, a stream of waste is bled from the basin continuously. The amount of water thus withdrawn is small when compared with the volume of make-up, due to the high rate of evaporation encountered in this arid country. Over a period of several months the scale deposition upon the atmospheric cooling sections is not sufficient to reduce the exchange value materially, and temperatures are obtained which are sufficient to operate the plant satisfactorily.


WANTED
. . . New FULTONS,
EDISONS and CHRYSLERS
The great strength of the United States is not its billions of gold, its tons of metal or its giant industrial capacity. It is the native mechanical skill and inventive power of its people.
In a crisis, this democracy always gives us the men and the ideas the nation needs.
Usually, we imagine that these ideas come from the scientific laboratories or from the drawing boards of engineers. Many do. But just as many and just as great ideas come from the men at the machines of industry.
For scientists, there is the Nobel Prize. For engineers, a score of awards. But there is no award for the gifted men now working at the lathes, forges and work benches of industry.
As a contribution to our national security, Revere Copper and Brass Incorporated is establishing an award of $10,000.00 for the workmen in America's metal working industries.
Donald Dallas
PRESIDENT
REVERE COPPER AND BRASS INCORPORATED

The REVERE AWARD

of $10,000 for Wage Earners in America's Metal Working Industries

THE Revere Award is made by Revere Copper and Brass Incorporated to help speed national defense by encouraging the mechanical genius and inventive talent of American wage earners.

The Revere Award totals $10,000.00 divided as follows:

1st Award	$5,000.00
2nd Award	2,500.00
3rd Award	1,000.00
4th to 9th Awards	250.00 each

The Revere Award is open to all wage earners (foremen and workingmen) in the metal and metal-working industries and to all machine maintenance men.

Each entry remains the property of the sender.

Selection will be made by an impartial Jury of Award consisting of men high in science, labor, the Army, the Navy and industry. The decision of the Jury of Award will be final.

Winners will be chosen for the inventions, devices, improvements or ideas which, in the Jury's opinion, contribute most to speeding up America's Defense Program.

It is desired that all entries be placed at the command of the Defense Advisory Council at Washington, D. C., subject to the entrant's own written consent.

Two or more men may cooperate in any entry.

Entries close on midnight, April 30th, 1941.

For booklet giving complete details of The Revere Award and for Entry Blanks simply write to THE REVERE AWARD COMMITTEE, P. O. Box 1805, Washington, D. C.

★ ★ ★ ★ ★

Expanding Business Bringing Stronger Markets

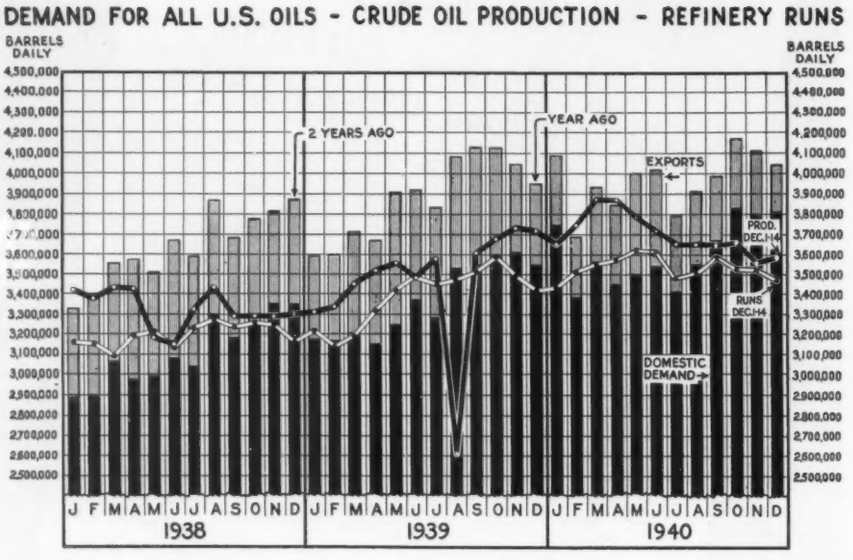
L. J. LOGAN

FOLLOWING the difficulties of 1940, prominent among which were the loss of export business and the sinking of gasoline prices to extremely low levels, materially improved conditions appear to be in store for the oil industry in 1941.

The industry faces the prospect of unprecedented demand for its products, despite possible further shrinkage of exports. And the indicated large demand promises to be doubly beneficial, by expanding volumes of business and by promoting stronger markets, with balancing of supply with demand made easier.

In short, oil companies apparently will be fortified in 1941 with the two fundamental requisites for satisfactory operations and earnings; namely, large volumes of business and comparatively favorable prices.

Not since 1937 has the New Year's outlook been quite as promising.


DEMAND FOR ALL U.S. OILS - CRUDE OIL PRODUCTION - REFINERY RUNS
BARRELS DAILY
2 YEARS AGO
YEAR AGO
EXPORTS
PROD. DEC.14
RUNS DEC.14
DOMESTIC DEMAND
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
1938
1939
1940

Source: Bureau of Mines, except data for November and December, 1940, which are estimates.

Heavy Fuel Situation

Standing out as a major problem for 1941 is the responsibility of providing adequate supplies of heavy fuel oil. Requirements will be exceptionally large, because of the prospective brisk industrial activity, and fulfillment of the demand will necessitate precautions against an attendant over-supplying of the requirements of other petroleum products less urgently needed.

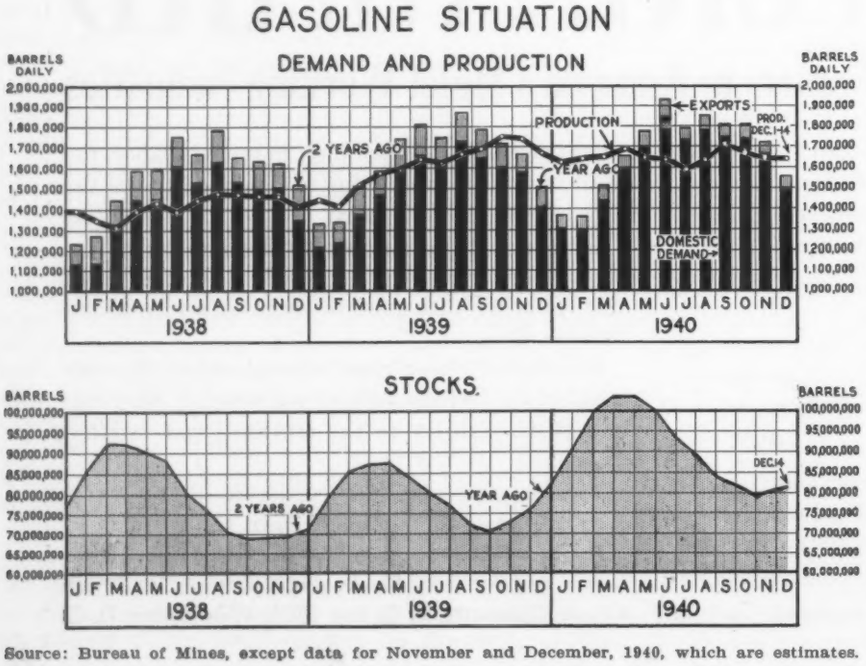
The Bureau of Mines went into this matter in considerable detail in its forecast for January, and indicated that prospective large demand for heavy fuel oil would require henceforth increased yields of the heavy oils at the refineries or increased imports, as alternatives to the running of more crude to stills than necessary for adequately supplying other products.

"A sharp rise in the demand for residual fuel oils is indicated as defense activities get into full production," stated the bureau. "Residual fuel stocks east of California, although several million barrels above the abnormally low level of last year, appear to be inadequate. As indicated in the December forecast, this situation would require either greater runs than are necessary for other products, increased yields, or larger imports."

Heretofore, the situation has been met by the industry by increasing yields of heavy fuel oils, as well as by bringing in larger quantities of crude and fuel oil from South America, under the Venezuelan agreement, which permits crude and fuel oil imports up to specified proportions at one half the regular tax rates.

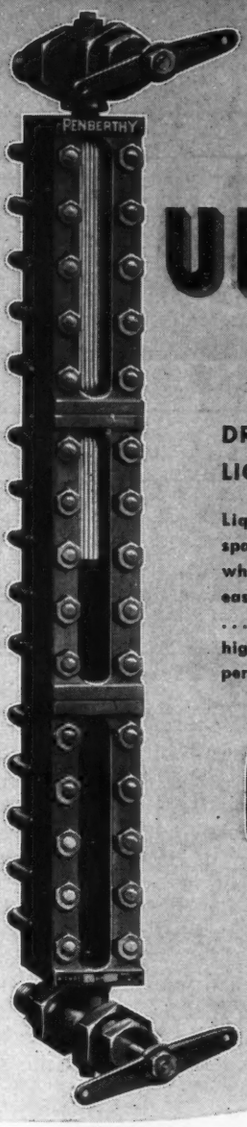
The industry, accordingly, was taking at the refineries in October a relatively low yield of gasoline, a normal distillate yield, and an increased residual yield; and it may be expected to continue the pursuance of a similar policy with regard to yields.

While heavy fuel oil is an impor-


GASOLINE SITUATION
DEMAND AND PRODUCTION
BARRELS DAILY
PRODUCTION
EXPORTS
PROD. DEC.14
2 YEARS AGO
YEAR AGO
DOMESTIC DEMAND
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
1938
1939
1940
STOCKS
BARRELS
2 YEARS AGO
YEAR AGO
DEC.14
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
1938
1939
1940

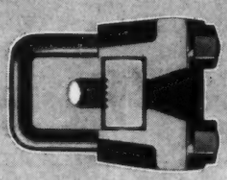
Source: Bureau of Mines, except data for November and December, 1940, which are estimates.

QUALITY UNCOMPROMISED



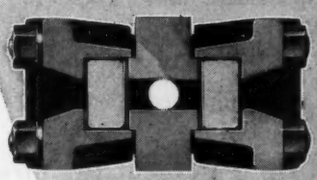
PENBERTHY
Reflex
DROP FORGED STEEL LIQUID LEVEL GAGES

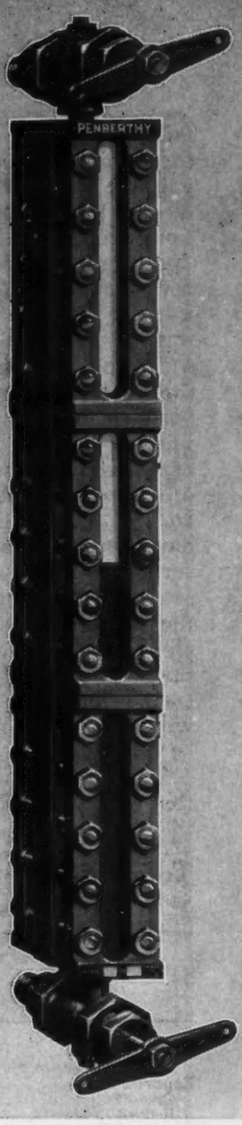
Liquid shows black—empty space shows white. Preferred wherever liquid level must be easily and positively visible . . . and when liquids are under high pressure or at high temperature.



PENBERTHY
Transparent
DROP FORGED STEEL LIQUID LEVEL GAGES

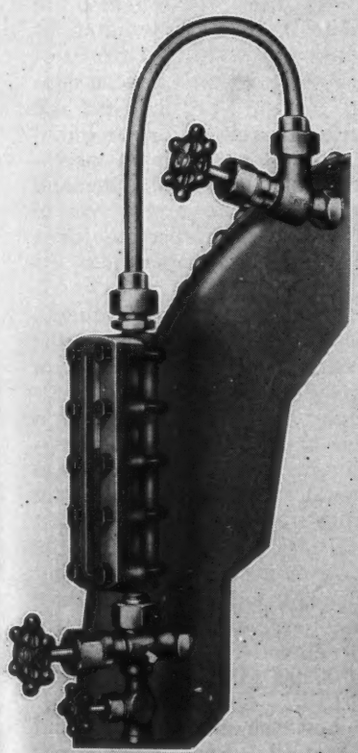
Used to observe color and density of liquids under high pressures, and/or temperatures. Construction is exceptionally rugged . . . similar to Reflex types.





Penberthy Liquid Level Gages

ALL PENBERTHY GAGES CONFORM WITH A. P. I.—A. S. M. E. REQUIREMENTS

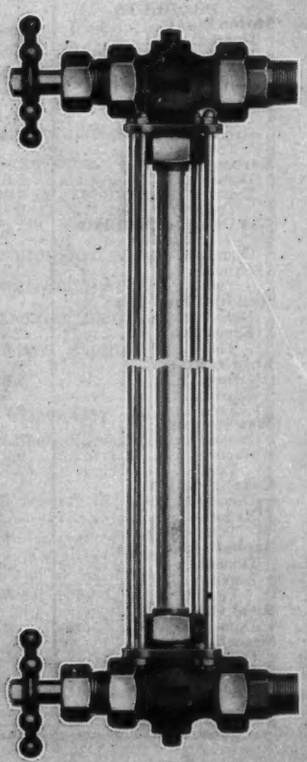


PENBERTHY
Reflex
WATER GAGE SET

Water shows black—steam shows white. U-bolt construction is strongest and simplest to service. Glass replaced by simply removing nuts on face of gage . . . unnecessary to work between gage and boiler.

PENBERTHY
DROP FORGED STEEL LIQUID LEVEL GAGES

Made of Chromium-molybdenum alloy temperature-resisting steel, extra heavy throughout. Stainless steel trimmed. Tubular glass type gages also available in various other metals suitable for practically all conditions.



PENBERTHY INJECTOR CO.

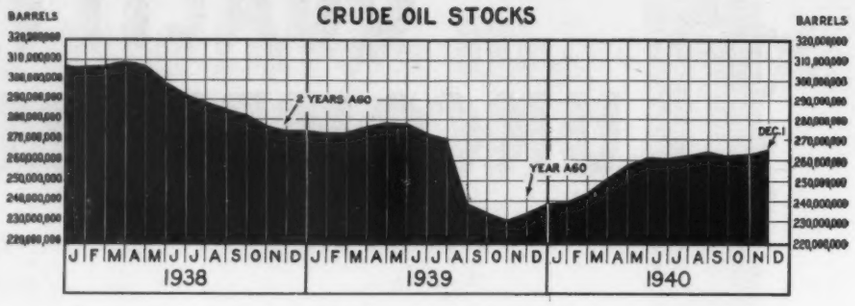
DETROIT, MICHIGAN • Canadian Plant: Windsor, Ontario

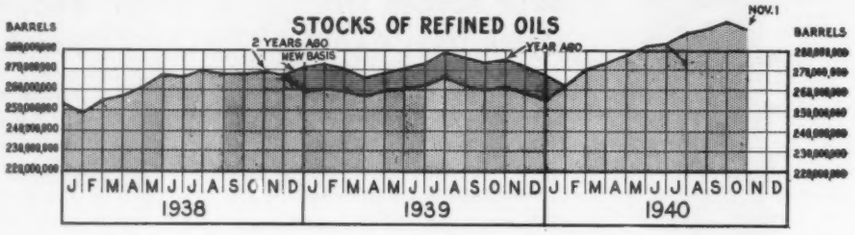
PENBERTHY PRODUCTS

tant product of the industry from the standpoint of volume involved, gasoline remains the principal refined oil and the one around which operations are shaped. The industry is encouraged, therefore, by the outlook for more wieldy gasoline stocks and a better gasoline market in the coming year.

During the past several months, the gasoline inventory situation has been materially improved, with refinery runs held down to fairly moderate proportions and with the yields of gasoline deliberately minimized. In relation to demand, the stocks have become increasingly more conservative. And although a normal seasonal build-up is indicated for the winter, stocks likely will not climb to the excessively high level that was reached at the beginning of last spring; and for the stocks that will be on hand, a larger market will be available.

The Bureau of Mines anticipated that stocks of finished and unfinished gasoline would be about 82,000,000 barrels on December 31, 1940, and said that a normal increase of at least 14,000,000 barrels seemed unavoidable for the first quarter of 1941. A peak of 96,000,000 barrels was foreseen as probable, therefore, for March 41, 1941, as compared with almost 104,000,000 barrels at that time in 1940. That expected stock position would represent a material improvement, the bureau pointed out, because of an expected increase of 6 to 7 percent in domestic motor-fuel demand during 1941 and also because the figure will include an increase of several million barrels in essential aviation gasoline stocks.




STOCKS OF REFINED OILS
BARRELS
2 YEARS AGO
NEW BASIS
YEAR AGO
NOV. 1
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
1938
1939
1940

Source of Data: Bureau of Mines.

Total Oil Demand Up 2 Percent for First 10 Months of 1940

Figures indicate barrels, and are from Bureau of Mines

	OCTOBER			FIRST TEN MONTHS		
	1939	1940	Percent Change	1939	1940	Percent Change
SUMMARY						
Total Demand	126,878,000	129,546,000	+ 2.1	1,173,431,000	1,200,875,000	+ 2.3
Daily Average	4,093,000	4,179,000	+ 2.1	3,860,000	3,937,000	+ 2.0
Exports:						
Crude Petroleum	6,947,000	5,269,000	— 24.2	62,097,000	45,721,000	— 26.4
Refined Products	9,804,000	6,044,000	— 38.4	100,509,000	68,027,000	— 32.3
Total Exports	16,751,000	11,313,000	— 32.5	162,606,000	113,748,000	— 30.1
Domestic Demand:						
Total Domestic Demand	110,127,000	118,233,000	+ 7.5	1,010,825,000	1,087,127,000	+ 7.6
Daily Average	3,552,000	3,814,000	+ 7.4	3,325,000	3,564,000	+ 7.2
TOTAL DEMAND FOR PRODUCTS						
Motor Fuel:						
Domestic	49,854,000	53,807,000	+ 7.9	464,295,000	493,937,000	+ 6.4
Exports	3,443,000	2,149,000	— 37.6	38,942,000	20,919,000	— 46.3
Total	53,297,000	55,956,000	+ 5.0	503,237,000	514,856,000	+ 2.3
Aviation Gasoline: (included above):						
Domestic	*	553,000	.....	*	4,317,000	.....
Exports	301,000	291,000†	— 3.3	3,588,000	3,263,000	— 9.1
Total	.....	844,000	.....	.....	7,580,000	.....
Kerosene:						
Domestic	5,019,000	5,608,000	+ 11.7	47,867,000	54,200,000	+ 13.2
Exports	1,107,000	142,000	— 87.2	7,022,000	3,068,000	— 56.3
Total	6,126,000	5,750,000	— 6.1	54,889,000	57,268,000	+ 4.3
Gas Oils and Distillate Fuels:						
Domestic	10,908,000	13,574,000	+ 24.4	107,138,000	127,321,000	+ 18.8
Exports	2,756,000	1,356,000	— 50.8	27,906,000	16,935,000	— 39.3
Total	13,664,000	14,930,000	+ 9.3	135,044,000	144,256,000	+ 6.8
Residual Fuel Oils:						
Domestic	28,323,000	29,976,000	+ 5.8	259,023,000	272,297,000	+ 5.1
Exports	1,296,000	1,366,000	+ 5.9	15,049,000	13,830,000	— 8.1
Total	29,619,000	31,342,000	+ 5.8	274,072,000	286,127,000	+ 4.4
Lubricants:						
Domestic	2,656,000	2,443,000	— 8.0	19,961,000	20,294,000	+ 1.7
Exports	985,000	654,000	— 53.6	9,381,000	9,274,000	— 1.1
Total	3,641,000	3,097,000	— 14.9	29,342,000	29,568,000	+ 0.8
Wax (pounds):						
Domestic	40,567,000	37,350,000	— 7.9	241,641,000	294,453,000	+ 21.9
Exports	19,210,000	10,636,000	— 44.6	205,689,000	169,830,000	— 17.4
Total	59,777,000	47,986,000	— 19.7	447,330,000	464,283,000	+ 3.8
Coke (short tons):						
Domestic	158,500	134,000	— 15.5	1,172,400	1,163,400	— 0.8
Exports	22,700	33,400	+ 47.1	235,100	233,600	— 0.6
Total	181,200	167,400	— 7.6	1,407,500	1,397,000	— 7.5
Asphalt (short tons):						
Domestic	543,000	647,800	+ 19.3	4,301,600	4,559,500	+ 6.0
Exports	3,500	21,600	+517.1	37,900	253,200	+568.1
Total	546,500	669,400	+ 22.5	4,339,500	4,812,700	+ 10.9
Road Oil:						
Domestic	577,000	683,000	+ 18.4	7,563,000	7,380,000	— 2.4
Miscellaneous:						
Domestic	173,000	189,000	+ 9.3	1,850,000	1,768,000	— 4.4
Exports	17,000	53,000	+211.8	91,000	834,000	+816.5
Total	190,000	242,000	+ 27.4	1,941,000	2,602,000	+ 34.1

* Not available. † Includes 132,000 barrels anti-knock compounds.

Over-All Outlook

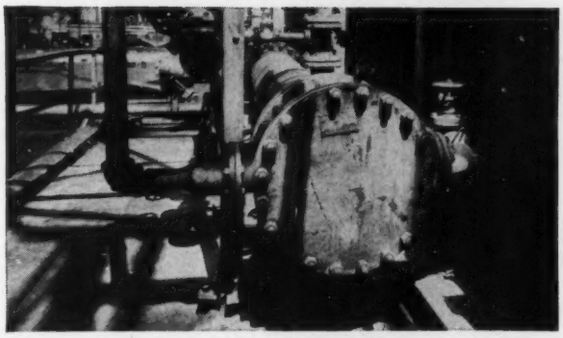
While heavy fuel oil and gasoline will be consumed in large quantities in 1941, other products also are expected to be in good demand. In the January forecast, the Bureau of Mines embodied a prediction on consumption for the year and for the first quarter as well as for the initial month, pointing out that it was necessary to consider the probable demand for all oils during the coming year to secure the proper perspective for a reasonable forecast of operations for the first quarter.

The bureau stated, accordingly, that an increase of 8 percent in the daily average demand for all oils in 1941, including special defense requirements and stocks, seemed a reasonable and conservative assumption, assuming no drastic changes in international relations. Such a gain would constitute an actual increase of about 102,000,000 barrels for the year. It was conceded, however, that a further loss in exports might reduce that figure to a 6-percent increase in the total demand for all oils, a gain of about 87,000,000 barrels in 1941 over 1940.

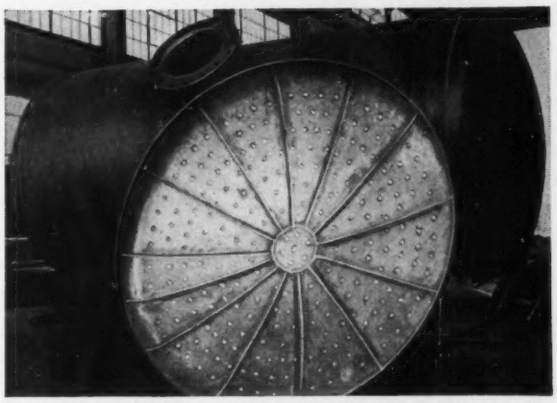
As to how the increased demand may be met, the Bureau of Mines

3 ECONOMICAL WAYS

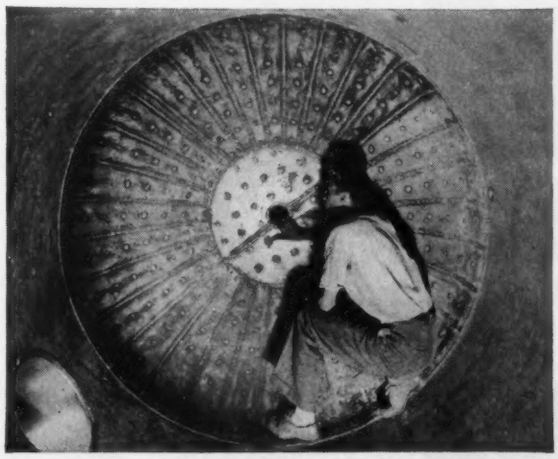
TO PROTECT NEW OR OLD EQUIPMENT AGAINST CORROSION...



Naphtha cooler with shell constructed of ¼" Nickel-Clad plate with 20% Nickel cladding. The cooler handles naphtha overhead from crude oil. The naphtha contains sulfides and chlorides with traces of phenol.



Monel-lined fractionating tower and head used in handling furfural. The tower is 6 ft. in dia. and 16 gauge Monel sheet was used for the lining which was plug welded to the steel on 6" centers. Built by Southwest Welding and Manufacturing Company, Alhambra, California.



Interior view of a 6 ft. I.D. by 17 ft. long accumulator drum with the head lined with 3/32" Monel sheet applied by plug welding and seam welding. Built by Black, Sivalls, and Bryson, Inc., Oklahoma City, Oklahoma.

NOT so expensive or difficult as you might think, is protection of new or existing equipment against corrosion. For Monel*, Nickel or Inconel* assure easy fabrication and long, economical service.

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Several patented methods are available for applying Monel, Nickel or Inconel to steel backing plate. Involving the use of spot or continuous resistance welding, they have proved O.K. for refinery and process equipment.

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Light gauge sheets of Monel, Nickel or Inconel are readily welded to the interiors of steel vessels. Examples of this method are the two lower photos.

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offered several definite suggestions. Almost half of the gain would be taken care of simply by maintaining crude production at the same daily average rate as in 1940, the agency pointed out, as the wells of the country during 1940 turned out about 40,000,000 barrels more oil than the markets absorbed, as evidenced by an increase of that amount in the stocks of all oils, crude and refined. Crude oil production in 1940 averaged about 3,700,000 barrels daily, according to the bureau, and consequently, that rate of production, in absence of any stock changes, would supply nearly half of the indicated 87,000,000-barrel increase in 1941 in the demand for all oils. The remaining increase of 47,000,000 barrels in the demand for all oils might be met, the agency suggested, by stock decreases of 10,000,000 barrels, by increased imports of 10,000,000 barrels, and by a gain in crude oil production of 27,000,000 barrels. This would indicate a daily average crude oil production of 3,775,000 barrels in 1941, an increase of 2 percent over 1940.

Having taken into consideration prospects for exports and imports and changes in stocks, the federal government agency calculated that an increase in crude runs to stills of over 4 percent was indicated—or an average rate of nearly 3,700,000 barrels daily for the whole year 1941.

Material expansion of demand beyond the above indicated proportions would necessitate increases in both crude production and runs to stills, the Bureau of Mines stated; and refinery operations east of California might be close to capacity, particularly if crude runs in the first quarter are at too low a level.

Gains in demand in 1941 as compared with 1940 will differ considerably for the several quarters of the year. Because of the abnormally high demand in the first quarter of 1940, the increase for the initial quarter of 1941 may be below the estimated average gain for the year. But the relative increase in subsequent quarters would be progressively greater.

The forecasts of demand and necessary crude runs for January as set forth by the Bureau of Mines in a table presented herewith were described by that agency as representing a minimum, and it pointed out that the figures might have to be increased in subsequent forecasts for February and March, if the trend of demand should prove greater than presently indicated as probable.

An over-all increase of 5.3 percent

Oil Exports Continue Down One Third From Year Ago

Figures indicate barrels, and are from Bureau of Mines

ITEM	FIRST TEN MONTHS 1939	FIRST TEN MONTHS 1940	FIRST TEN MONTHS Percent Change	MONTH OF OCTOBER 1939	MONTH OF OCTOBER 1940	MONTH OF OCTOBER Percent Change
Crude Oil	62,097,000	45,721,000	— 26.4	6,947,000	5,269,000	— 24.2
Products:						
*Motor Fuel	38,942,000	20,919,000	— 46.3	3,443,000	2,149,000	— 37.6
Aviation Gasoline (included above)	3,588,000	3,263,000	— 90.6	287,000	291,000†	+ 1.4
Kerosene	7,022,000	3,068,000	— 56.3	1,107,000	142,000	— 87.2
Gas Oil and Distillate	27,906,000	16,935,000	— 39.3	2,756,000	1,356,000	— 50.8
Residual Fuel Oil	15,049,000	13,830,000	— 8.1	1,296,000	1,366,000	+ 5.4
Lubricants	9,381,000	9,274,000	— 1.1	985,000	654,000	— 33.6
Wax (pounds)	205,689,000	169,830,000	— 17.4	19,210,000	10,636,000	— 44.6
Coke (short tons)	235,100,000	233,600,000	— 0.6	22,700,000	33,400,000	+ 4 .1
Asphalt (short tons)	37,900,000	253,200,000	+ 85.0	3,500,000	21,600,000	+ 517.1
Miscellaneous Oils	91,000	834,000	+ 89.1	17,000	53,000	+ 211.8
‡Total Refined Products	100,509,000	68,027,000	— 32.3	9,804,000	6,044,000§	— 38.4
Total Crude and Products	162,606,000	113,748,000	— 30.1	16,751,000	11,313,000	— 32.5

* Includes Benzol 1,000 barrels in October, 1940. † Includes 132,000 barrels anti-knock compounds.
‡ Not sum of the above figures, some of which do not indicate barrels. § Exclusive of 8,000 barrels exports from non-contiguous territories but inclusive of 1,119,000 barrels shipped from United States to territories.

Changes from Year Ago in Stocks of Crude and Refined Oils in the United States

(Figures indicate barrels)

LATEST WEEKLY DATA

(Sources: Crude stocks, Bureau of Mines: all other figures American Petroleum Institute).

STOCKS OF	December 21, 1939	December 21, 1940	Percent Change
Gasoline	80,905,000	81,870,000	+ 1.2
Gas Oil & Distillate	35,063,000	42,260,000	+20.5
Residual Fuel Oil	107,149,000	102,841,000	— 4.0
Crude Oil	*232,615,000	†261,293,000	+ 1.2

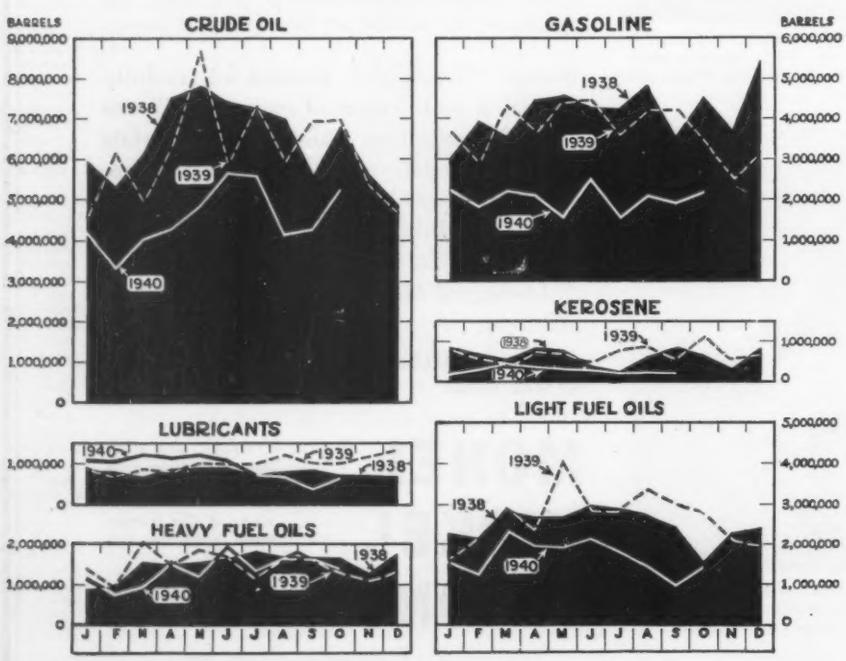
LATEST MONTHLY DATA

(Source: Bureau of Mines)

ITEM	Stocks at End of October 1939	1940	Percent Change
SUMMARY—			
Crude Petroleum:			
Refinable in U.S.	231,852,000	263,856,000	+ 13.8
Heavy in California	14,070,000	12,353,000	— 12.2
Natural Gasoline	5,140,000	6,569,000	+ 27.8
Refined Products	275,854,000	290,918,000	+ 5.5
Total, all Oils	526,916,000	573,696,000	+ 8.9
Day's Supply:			
October Basis	129	137	+ 6.2
10 Months Basis	136	146	+ 7.4
PRODUCTS—			
Gasoline:			
Finished	68,116,000	73,338,000	+ 7.7
Unfinished	5,203,000	5,847,000	+ 12.4
Total	73,319,000	79,185,000	+ 8.0
Aviation Gasoline (included above)	2,400,000	6,142,000	+155.9
Kerosene	9,967,000	11,000,000	+ 10.4
Gas Oil & Distillate Fuels	40,093,000	49,037,000	+ 22.3
Residual Fuel Oils	99,921,000	94,658,000	— 5.3
Lubricants	6,639,000	8,464,000	+ 27.5
Wax (pounds)	81,147,000	113,827,000	+ 40.3
Coke (short tons)	652,000	581,000	+ 10.9
Asphalt (short tons)	472,000	469,000	— 0.6
Road Oil	715,000	719,000	+ 0.6
Miscellaneous	289,000	341,000	+ 18.0
Other Unfinished Oils	38,765,000	41,623,000	+ 7.4

* Stocks on hand December 16, 1939.
† Stocks on hand December 14, 1940.

U. S. Exports of Crude Petroleum and Refined Products



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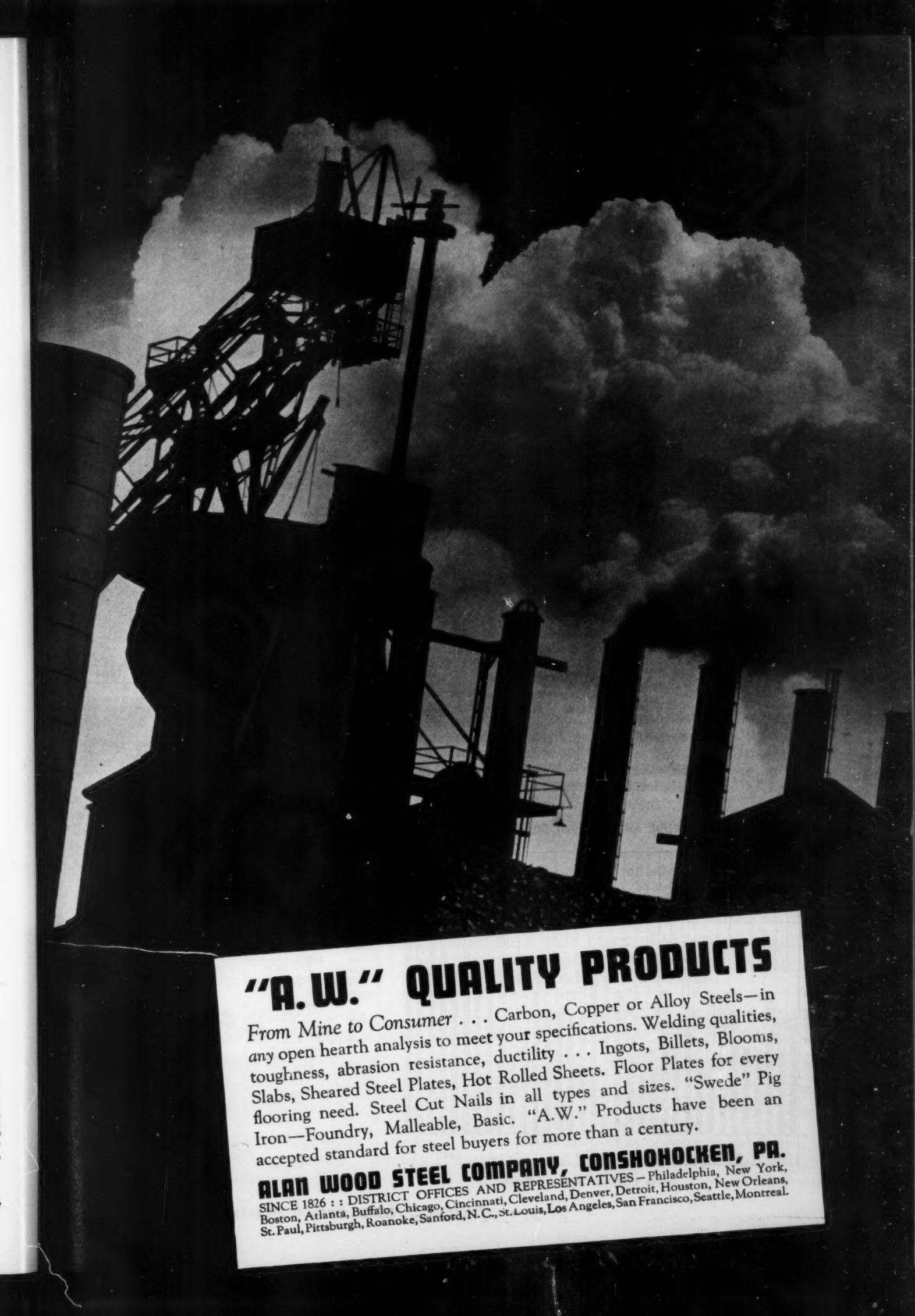

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in motor fuel demand was forecast by the Bureau of Mines for January, 1941, as compared with January, 1940. Domestic demand was estimated at 43,000,000 barrels for the month, or 6.5 percent higher than the actual demand for January, 1940. The estimate for exports of motor fuel, based on forecasts by the principal exporters, was 1,900,000 barrels. That was 100,000 barrels more than the December estimate but 374,000 barrels, or 16.4 percent, lower than the actual for January, 1940.

Aside from the current domestic and export demand for 44,900,000 barrels of gasoline in January, the bureau foresaw that the industry would accumulate 6,300,000 barrels in storage, as compared with the 7,500,000 barrels stored in January, 1940.

As the supplies to balance against the current domestic and export demand and the expected accumulation in storage, the Bureau of Mines foresaw benzol production and direct sales of natural gasoline in the amount of 1,500,000 barrels and refinery production that necessarily would total 49,700,000 barrels. Natural gasoline to be blended at refineries was estimated as 7.1 percent of the total refinery production, or 3,520,000 barrels, leaving 46,180,000 barrels to be produced as straight-run and cracked gasoline. On the basis of a yield of 42.6 percent, that production would require the running of 108,420,000 barrels of domestic and foreign crude to refinery stills, of 3,497,400 barrels daily.

Runs of foreign crude were estimated at 3,700,000 barrels for January, or 849,000 barrels higher than in January, 1940, and the remainder of the refinery requirements were indicated as coming necessarily from production or stocks of domestic crude. And in addition, crude oil required for export was estimated at 3,900,000 barrels, the same as the November and December forecasts, while crude oil to be used for fuel and losses was estimated as 2,700,000 barrels. Total demand for domestic crude oil in January was indicated by those figures as 111,320,000 barrels, or 3,591,000 daily.

Summary of Bureau of Mines Forecasts for January, 1941

(Barrels)

	Forecast January, 1941	Forecast December, 1940	Actual January, 1940	Percent Change for January, 1940-1941
Demand for Motor Fuel*:				
Domestic demand	43,000,000	46,400,000	40,370,000	+ 6.5
Exports	1,900,000	1,800,000	2,274,000	—16.4
	44,900,000	48,200,000	42,644,000	+ 5.3
Supply of Motor Fuel:				
Straight-run and cracked gasoline production	46,180,000	46,200,000	45,700,000	+ 1.0
Natural gasoline used at refineries	3,520,000	4,020,000	3,285,000	+ 7.1
Total refinery production	49,700,000	50,220,000	48,985,000	+ 1.4
Benzol and other natural gasoline	1,500,000	1,180,000	1,203,000	+24.7
Imports	.....	.....	18,000	.....
Decrease in finished stocks	.....	.....	.....	.....
Increase in finished stocks	6,300,000	3,200,000	7,562,000	—16.7
Available supply	44,900,000	48,200,000	42,644,000	+ 5.3
Crude Oil Requirements:				
Percent yield of gasoline from crude	42.59	43.00	42.90	— 0.7
Refinery crude required	108,420,000	107,460,000	106,530,000	+ 1.8
Daily average	3,497,400	3,466,500	3,436,500	+ 1.8
Foreign crude runs	3,700,000	3,600,000	2,851,000	+29.8
Exports	3,900,000	3,900,000	4,202,000	— 7.2
Fuel and losses	2,700,000	2,600,000	3,356,000	—19.5
Total demand for domestic crude	111,320,000	110,360,000	111,237,000	+ 0.1
Daily average	3,591,000	3,560,000	3,588,300	+ 0.1
Increase in domestic stocks	.....	.....	1,903,000	.....
Actual production	.....	.....	113,140,000	.....
Daily average	.....	.....	3,649,700	.....

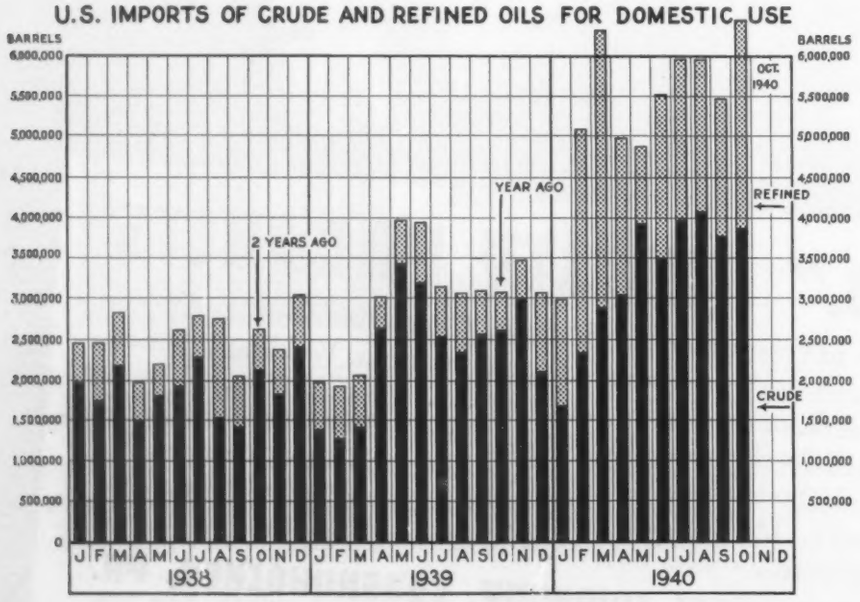
* The term "Motor Fuel" as used in this report includes gasoline, naphtha, and benzol used for all purposes, but does not include heavier distillates used in the operation of tractors or burned in Diesel engines.

Oil Imports for Domestic Use Up Sharply

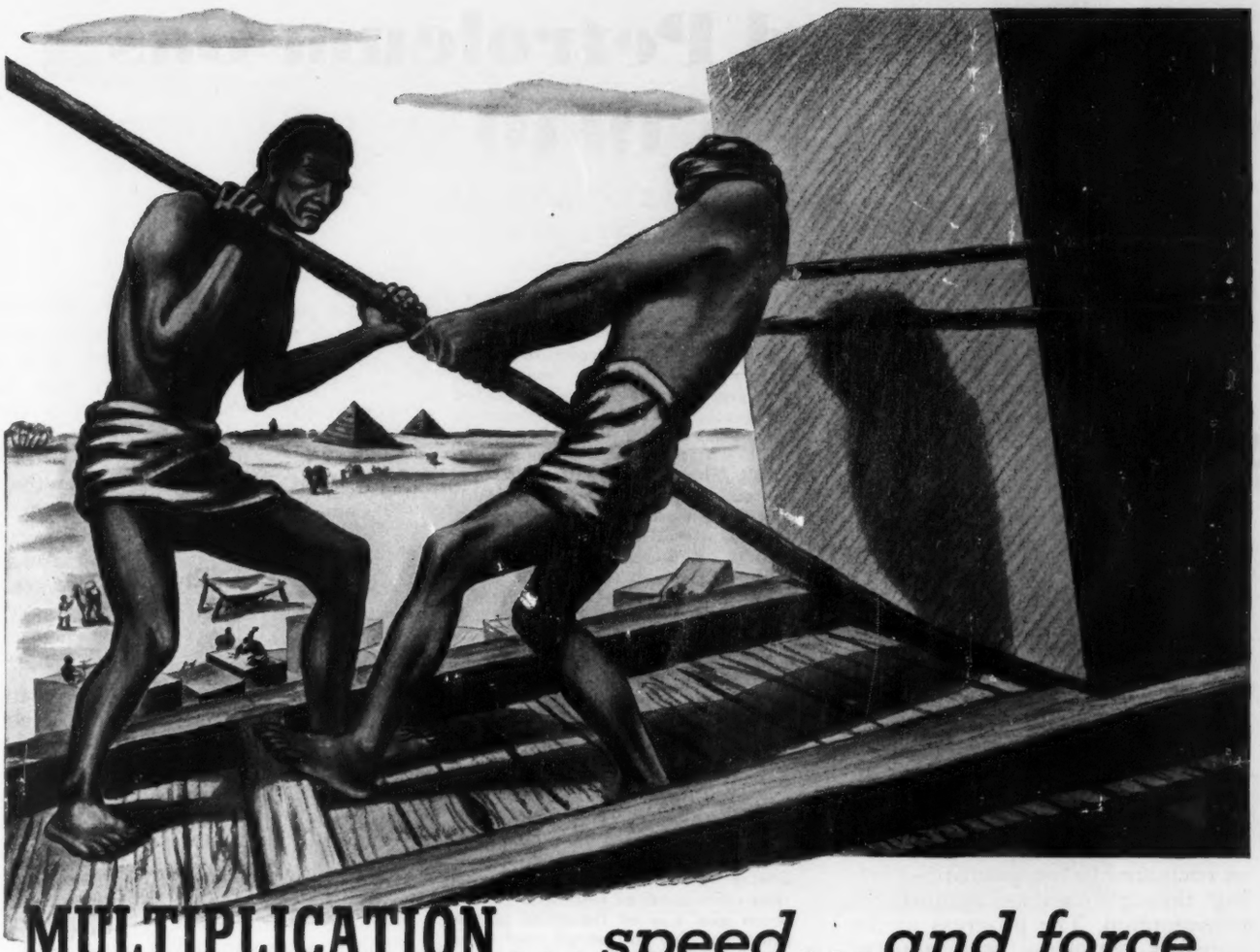
Figures indicate barrels and are from Bureau of Mines.

MONTH	Crude Oil	Refined Products	Total
January:			
Jan., 1939	1,373,000	609,000	1,982,000
Jan., 1940	1,664,000	1,321,000	2,985,000
Change	+21.2%	+117.1%	+52.0%
February:			
Feb., 1939	1,266,000	654,000	1,920,000
Feb., 1940	2,343,000	2,731,000	5,074,00
Change	+85.0%	+320.0%	+164.0%
March:			
Mar., 1939	1,404,000	659,000	2,063,000
Mar., 1940	2,895,000	3,410,000	6,305,00
Change	+106.2%	+417.4%	+205.6%
April:			
April, 1939	2,648,000	366,000	3,014,000
April, 1940	3,041,000	1,948,000	4,989,000
Change	+14.8%	+432.0%	+65.5%
May:			
May, 1939	3,434,000	529,000	3,963,000
May, 1940	3,921,000	934,000	4,855,000
Change	+14.2%	+76.5%	+22.5%
June:			
June, 1939	3,196,000	750,000	3,946,000
June, 1940	3,488,000	2,056,000	5,544,000
Change	+9.1%	+174.1%	+40.5%
July:			
July, 1939	2,539,000	608,000	3,147,000
July, 1940	3,981,000	2,000,000	5,981,000
Change	+56.8%	+228.9%	+90.0%
August:			
Aug., 1939	2,346,000	717,000	3,063,000
Aug., 1940	4,074,000	1,898,000	5,972,000
Change	+73.7%	+164.7%	+95.0%
September:			
Sept., 1939	2,553,000	541,000	3,094,000
Sept., 1940	3,772,000	1,712,000	5,484,000
Change	+47.1%	+216.5%	+77.2%
October:			
Oct., 1939	2,605,000	1,741,000	3,965,000
Oct., 1940	3,741,000	3,122,000	6,863,000
Change	+43.6%	+79.3%	+73.1%
1st 10 Months:			
1939	23,364,000	5,858,000	29,222,00
1940	32,920,000	21,052,000	53,972,000
Change	+40.9%	+259.4%	+84.7%

U.S. IMPORTS OF CRUDE AND REFINED OILS FOR DOMESTIC USE



Source of Data: Bureau of Mines.



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Liquefied Petroleum Gas in 1940

G. G. OBERFELL, Vice President
Phillips Petroleum Company

THE liquefied petroleum gas industry continued its march of progress in 1940. The accompanying Table 1 shows the estimated marketed production of liquefied petroleum gas during 1940 with an indicated total of 300,000,000 gallons as compared to 223,580,000 gallons marketed in 1939, an increase of 32.5 percent. Highly specialized sales efforts in the domestic field, increased industrial activities resulting from generally better business conditions, and to a minor extent from the National Defense Program account for much of this very substantial gain.

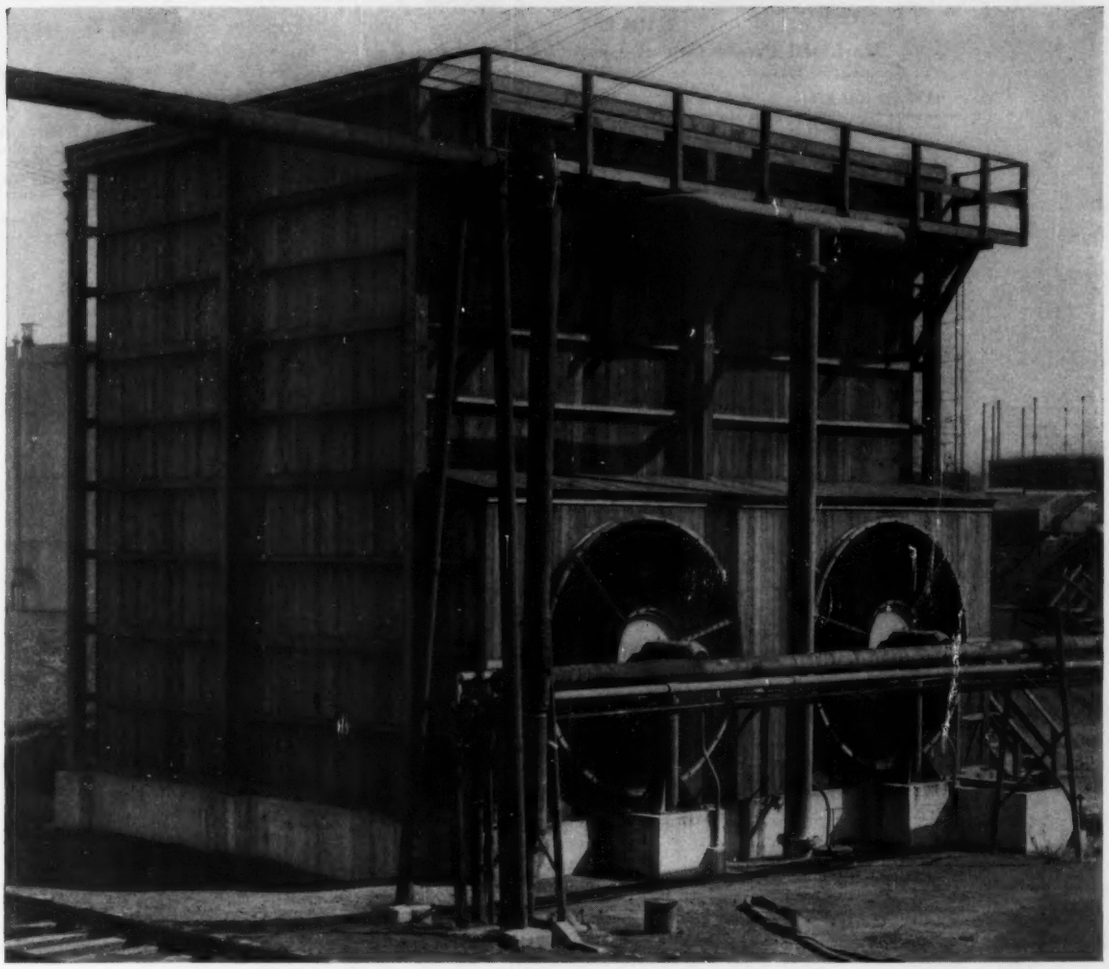
Table 2 and the accompanying chart are of particular interest in that they show the total potentially available supply of propane and butane existing at all sources as compared to the quantities moving through various channels of consumption. The progress of the liquefied petroleum gas industry during the past year as well as during the last several years has been in itself very gratifying, but from the viewpoint of the petroleum industry as a whole it is important to note that the volumes of propane and butane marketed as such are only a relatively minor portion of the total supply and a small part of the amount used in motor fuel. About 3 percent of the total potentially available propane-butane supply is sold as liquefied gas; and this amount is less than 10 percent of the volumes of these gases used in the production of gasoline by blending or through various polymerization processes.

THE liquefied petroleum gas industry continued its march of progress in 1940. The marketed production in the United States is estimated at 300,000,000 gallons, an increase of 32.5 percent over 1939. The number of retail customers using liquefied petroleum gas for domestic fuel is now well beyond the million mark, the estimated total being 1,125,000 at the end of 1940, an increase of 325,000. While the progress of the liquefied petroleum gas industry itself has been very gratifying it is interesting to note that, from the viewpoint of the petroleum industry the volume of propane and butane sold as liquefied petroleum gas is only 3 percent of the potentially available supply and only 10 percent of the amount of these gases blended into gasoline or made into motor fuel by polymerization processes. Any requirements for the synthetic rubber industry probably will not exceed that consumed as liquefied petroleum gas. Use of liquefied petroleum gas for industrial fuel continues its healthy growth: its use by utility companies in recent years has been continuing at an accelerated but moderate pace. Uniform safety standards are fast being adopted throughout the country.

One of the Largest Liquefied Petroleum Gas Plants

Home Use

The estimate for 1940 consumption of liquefied petroleum gas for home uses amounts to 128,000,000 gallons, which is an increase of 46.3 percent over the previous year. On the basis of the best information available, the number of new home users of liquefied petroleum gas increased approximately 325,000 during the year, the largest increase secured in any year. Territories where buried or underground systems are more commonly used account for about 50,000 of these new customers, a larger portion being acquired by distributors employing aboveground or replaceable cylinder systems. This year's record is important in another respect also since it is the year in which the number of retail customers passed the million mark, the estimated total now being 1,125,000. Greater public acceptance of liquefied petroleum gas as a domestic fuel due to improvements in economy, efficiency, variety and convenience of gas consuming appliances, increased sales efforts, a a larger number of distributors and larger advertising expenditures have been important influences in expanding home use of these highly efficient fuels. In many sections of the south and southwest where distribution is from nearby manufacturing centers, the number of rural and suburban homes completely equipped with liquefied petroleum gas for cooking, water heating, refrigeration and house heating is showing rapid develop-



Mechanical Draft cools 138,000 gallons per hour

The pioneer refiner to use Foster Wheeler mechanical draft cooling towers recently encountered the need for 138,000 gallons of cooling water per hour to serve a reforming unit.

Little space was available near the unit but due to its compactness, a low head, forced draft tower was installed between a fire bank, a yard track, and a permanent steam line. This provided short water lines, inexpensive installation, and no changes in the general refinery plot plan.

Outstanding characteristics of Foster Wheeler cooling towers for refineries include: 1. Permits location in crowded zones since cooling is by mechanical draft and positive even at zero wind velocity . . . 2. Saves water make-up and excessive pumping charges . . . 3. Reduces basin construction, frequently an overlooked item in first cost . . . 4. Permits cell additions for increased capacity.

FOSTER WHEELER CORPORATION, 165 BROADWAY, NEW YORK, N. Y.

WHEELER FW

TABLE 1
Marketed Production of Liquefied Petroleum Gas

YEAR	TOTAL SALES		DISTRIBUTION—Gallons Per Year					
	Gallons Per Year	Percent Increase Over Previous Year	Retail (Bottled Gas)	Percent Increase Over Previous Year	Industrial and Miscellaneous	Percent Increase Over Previous Year	Gas Manufacturing	Percent Increase Over Previous Year
1922	222,641	....						
1923	276,863	24.4						
1924	376,488	36.0	Sale of liquefied petroleum gas confined primarily to bottled gas business prior to 1928.					
1925	403,674	7.2						
1926	465,085	15.2						
1927	1,091,005	134.6						
1928	4,522,899	314.6	2,600,000	....	400,000	....	1,500,000	....
1929	9,930,964	119.6	5,900,000	126.9	1,500,000	275.0	2,500,000	66.7
1930	18,017,347	81.4	11,800,000	100.0	2,200,000	46.7	4,000,000	60.0
1931	28,769,576	59.7	15,294,648	29.6	7,171,686	226.0	6,303,242	57.6
1932	34,114,767	18.6	16,244,103	6.2	8,167,194	13.9	9,703,470	53.9
1933	39,931,008	14.1	16,625,588	2.3	13,987,095	71.3	8,318,325	—14.3
1934	56,427,000	44.9	17,681,000	6.3	32,448,000	132.0	6,298,000	—24.3
1935	76,855,000	36.2	21,380,000	20.9	47,894,000	47.6	7,581,000	20.4
1936	106,652,000	38.8	30,014,000	40.4	67,267,000	40.5	9,371,000	23.6
1937	141,400,000	32.7	40,823,000	36.0	89,402,000	32.9	11,175,000	19.3
1938	165,201,000	16.7	57,832,000	41.7	94,983,000	6.2	12,386,000	9.8
1939	223,580,000	35.3	87,530,000	51.3	120,615,000	27.0	15,435,000	24.6
1940	300,000,000	32.5	128,000,000	46.3	153,000,000	27.0	19,000,000	23.4

TABLE 2
Distribution of Total Potential Supply of Butane—Propane in U. S. Refineries and Gasoline Plants*

	MILLIONS OF GALLONS PER YEAR				
	Marketed as L.P.G.	Used in Manufacture of Gasoline	Used in Plant Fuel Gas	Left in Residue Gas	Total
Butane	170	2850†	250	1130	4400
Propane	130	750‡	1620	2250	4750
Total	300	3600	1870	3380	9150

* Estimated by writer. † By Blending and Polymerization. ‡ By Polymerization.

Remarks: In the above table "Total Sales" for all years except 1940 were obtained from U. S. Bureau of Mines reports. "Distribution" for the years 1931 to 1939, inclusive was obtained from the same source. All other volumes are estimated by the writer. The total sales volume includes all liquefied petroleum gases (propane, butane, and propane-butane mixtures) when sold as such. It includes the sale of pentane when sold for any purpose other than motor-fuel blending. It does not include butane when blended with heavier petroleum fractions for motor-fuel purposes. Inter-company sales transactions, such as purchases of liquefied petroleum gases by one company from other companies and then resold as liquefied petroleum gases, have been eliminated in order to avoid duplication of sales figures. The data do not reflect sales of liquefied petroleum gases used directly by the producer at the point of production, for fuel, polymerization, solvent, de-waxing, etc. Neither do the figures include sales of gaseous mixtures of hydrocarbons delivered by pipe line to the few large chemical plants which are adjacent to the points of production of these raw materials; such sales are included if liquefied petroleum gases are in liquid form when sold.

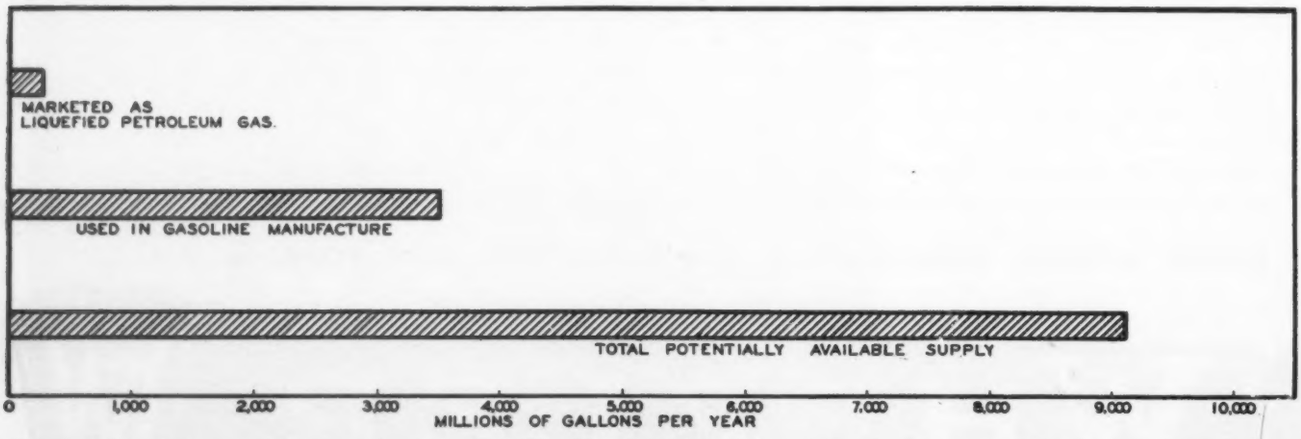
ment. In many sections of the country, the competition of electricity for cooking has been reduced materially. Electricity remains, however, the chief competitor of the liquefied petroleum gas industry in the home for cooking, refrigeration, and, to a lesser extent, for automatic hot water heating.

The acceleration in the nation's industrial output experienced in 1939 continued during the current year. Higher industrial activity has required more fuel in the form of butane and propane and, with an increased number of users in the industrial field, the liquefied petroleum gas industry has shared in the increased volume of business, as is evidenced by the estimated 27 percent gain in industrial sales volume.

A number of noteworthy installations were made during 1940 in industrial plants where natural gas in the past has been available from fields now showing rapid declines, liquefied petroleum gas is standing by as an emergency fuel or is completely replacing the diminishing natural gas supply. Several new industrial plants have been equipped to use butane or propane as fuel, some of these being in locations where manufactured or natural gas is not available.

Use in Engines

The use of liquefied petroleum gas in the operation of internal-combustion engines on construction equipment, well-drilling rigs, railroad locomotives, and railroad passenger car air-conditioning and electric generator units, continues to be an important factor in the expansion of the industry's mar-



Demand for Butane and Propane in Liquefied Petroleum Gas Industry and in Manufacture of Gasoline as Compared to Potential Supply.

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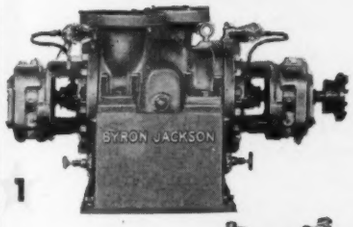

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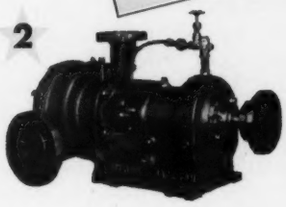

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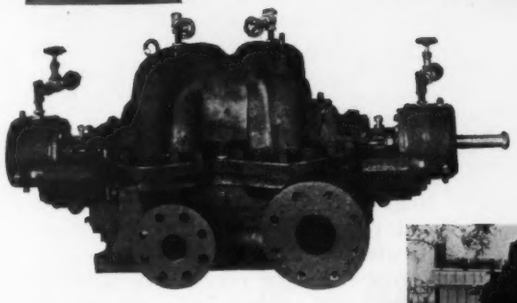

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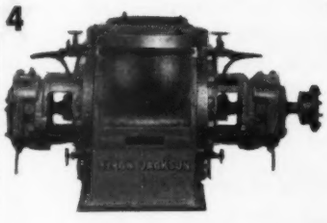

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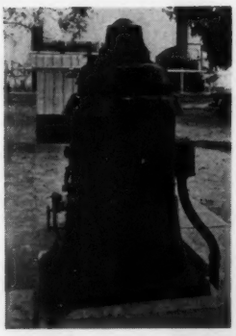

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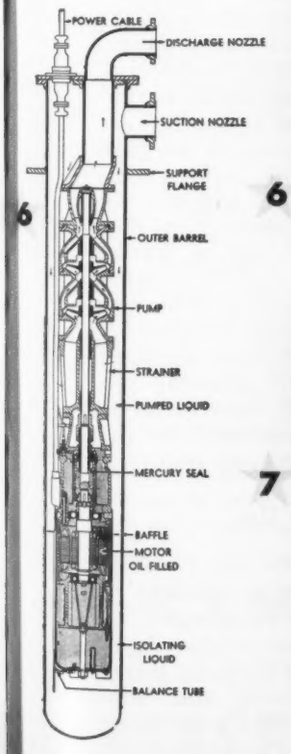

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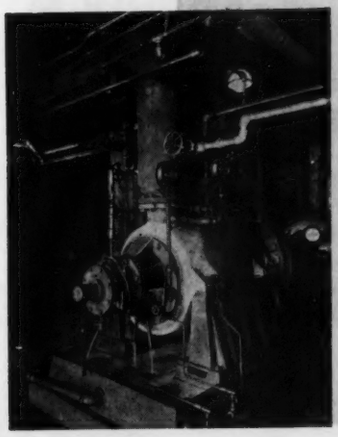

8

1. The vertically-split case, with circular gasket, is one of numerous safety features of BYRON JACKSON VC PUMPS that appeal to modern refinery operators. They are furnished in different sizes to handle from 20 to 4,000 G.P.M. of oil, at temperatures from 300 to 850 degrees F., on differential pressures up to 350 pounds per square inch.

2. Byron Jackson BM PROCESS Pumps are heavy duty, single stage pumps designed to operate on various pressures where conditions are too severe for ordinary pumps. The overhung construction, with the case supported at a circular fit concentric with the shaft, and water-jacketed stuffing box and bearings, permits the use of these pumps on high temperatures. Complete access to the pump is possible by removal of the end cover, without disturbing any piping. These pumps are made in sizes from 1 inch to 14 inches for capacities varying from 10 to 7,000 g.p.m.

3. Byron Jackson MULTIPLEX Pumps are made with from 2 to 8 stages, to meet a wide demand for rugged, compact, inexpensive multi-stage pumps for all classes of medium high head pumping service. The Type SD MULTIPLEX (pictured) is a horizontal, split case unit, having the internal cross-over passages between stages cast integral with the case, and with an even number of stages. Impellers are "paired" back-to-back to equalize end thrust. = Capacity Range: 50 to 4,000 g.p.m.; Head Range: 100 to 1,000 feet.

4. Modern features of Byron Jackson SINGLE STAGE DOUBLE SUCTION Pumps include: Center support under nozzles eliminates pipe strains with resultant misalignment at high temperatures—Case and cover sealed by two circular gaskets in recessed seats, only one of which is broken to dismantle pump—Nozzles cast integral with case for disassembly without disturbing piping—Vertical nozzle arrangement simplifies piping and eliminates vapor binding in the suction—Two stuffing boxes at suction pressure—Negligible bearing loads—Field of application, 800 to 3,000 G.P.M. at temperatures up to 800 degrees F., against heads of 250 to 800 feet. A single suction type, designed to overcome previous objections to single suction construction, will deliver from 15 to 800 G.P.M., at temperatures up to 800 degrees F., against heads from 75 to 400 feet.

5. Byron Jackson DEEPWELL TURBINE Pumps are world-famous for dependable, low-cost water supply service. The unit pictured is installed at Continental Oil Company's record-breaking Ville Platte Field Stabilization, Gasoline Recovery and Pressure Maintenance Plant. Byron Jackson DEEPWELL TURBINE Pumps are available in a variety of types for capacities from 25 to 10,000 g.p.m., at heads from 50 to 800 feet.

STUFFINGBOXLESS PUMP

6. For pumping Butane, Propane and Gasoline, the advantages of STUFFINGBOXLESS Pumps are immediately apparent, as the fire hazard is almost completely eliminated, and no loss of the valuable liquid can occur. The electric motor and pumping unit are totally enclosed in a sealed barrel, thus eliminating all stuffing boxes and all contact with the atmosphere. The pump and special motor operate immersed in the liquid being pumped, and are cooled by it, yet the bearings operate in oil, and the pumped liquid does not contact the active parts of the motor. An illustrated folder giving complete details will be furnished promptly to any oil man requesting it.

HYDROPRESS

7. The HYDROPRESS is designed for relatively small capacities combined with high pressures, and offers many advantages not possible with reciprocating pumps, nor with standard centrifugals. The vertical construction makes it compact, with resultant savings in space, and with bearing loads reduced to a minimum. Features include continuous, uniform, non-pulsating flow; variable capacities without by-pass or change of speed; elimination of relief valves; avoidance of stuffing box troubles due to the single packing gland which is subject to suction pressure only. The HYDROPRESS is an ideal pump for high head booster pumping service; hot or cold oil refinery service; oil well re-pressuring; where capacities range from 10-250 g.p.m., against heads from 200-10,000 feet.

BYRON JACKSON DOUBLE CASE PUMPS

8. These units meet the most exacting requirements of high pressure, high temperature pumping. The high degree of safety provided by double-case design, and other features, is evidenced by a twelve-year period of service, during which hundreds of these pumps have been marketed. Made in two types to provide capacities from 150-2,000 g.p.m. against heads 800-10,000 feet. The CONDENSED GENERAL BULLETIN contains complete descriptions and illustrations; a copy awaits your request.

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Houston • Chicago • New York

Established 1872

BYRON JACKSON

CENTRIFUGAL PUMPS FOR EVERY SERVICE

kets. Butane-fueled irrigation pumping engines in Texas and New Mexico are being installed at an increasing rate. The railroads continue to expand their use of liquefied petroleum gas as a motive power fuel in gas-engine-operated motor cars and small trains, and are finding increasing advantage in in the use of propane for cooking and water heating in dining cars and for the operation of car air-conditioning and electric generating units. It appears that for small locomotive power units for railroad use, liquefied petroleum gas offers many advantages because of fuel economy, lower engine maintenance costs and particularly low initial investment.

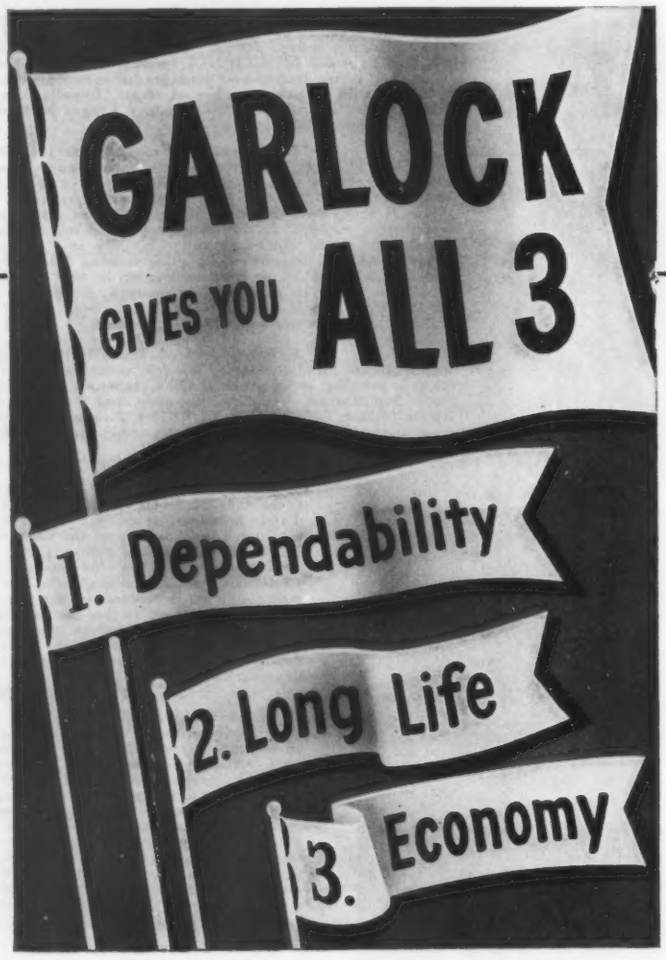
In California, the use of liquefied petroleum gas in internal-combustion engines on construction equipment and to a certain extent on heavy-duty transport trucks continues to increase. Similar applications in the Mississippi Valley are developing slowly. In sections of Oklahoma, New Mexico, Texas and Louisiana where substantial amounts of liquefied petroleum gas are hauled long distances by tank truck, the truck engines in the majority of cases use liquefied petroleum gas as fuel.

The use of butane and propane by the gas industry in small-city gas plants and in certain other applications in larger gas-manufacturing plants continued to show some increase as indicated by the 23.5 percent gain over the 15,435,000 gallons used in 1939 to an estimated 19,000,000 gallons in 1940. The merchandising of liquefied petroleum gas by utility companies beyond their gas mains has shown no developments worthy of comment. It appears that existing liquefied petroleum gas distributors are doing an excellent job of handling this type of market, particularly in the metropolitan and suburban areas surrounding the larger cities. The use of butane and propane as natural gas substitutes during peak demands continues to be of increasing interest to the utility gas industry and it is expected that substantial volumes will be required for this purpose during the present winter months. The use of propane and butane by utility companies to meet peak-load gas demands has shown that many economic and operating advantages can be gained by such methods of producing substitute gas.

The manufacture of synthetic rubber from petroleum products received considerable publicity during 1940. Certain synthetic rubber processes now operating are utilizing hydrocarbons as the base raw material and only future developments will serve to indicate the quantity of such hydrocarbons that will be needed. It may be stated, however, that potential sources will be more than sufficient for any near future synthetic rubber demand and the quantities required for some time will probably not exceed an amount equivalent to that now being marketed by the liquefied petroleum gas industry.

Safe to Use

The industry continues to enjoy a fine record of safe practices in the storage and distribution of its products. The latest safety standards adopted by the National Board of Fire Underwriters and published in July, 1940, incorporate all of the various standards formerly published separately. Those organizations that cooperated with the National Board of Fire Underwriters in this work are deserving



These three qualities are essential for superior packing performance: 1. *Dependability* even under the most severe service conditions; 2. *Long Life* that prevents frequent shutdowns for repacking; 3. *Economy* that keeps down maintenance costs. Garlock gives you *all three.* For outstanding service, standardize on GARLOCK — the standard packing of the world.

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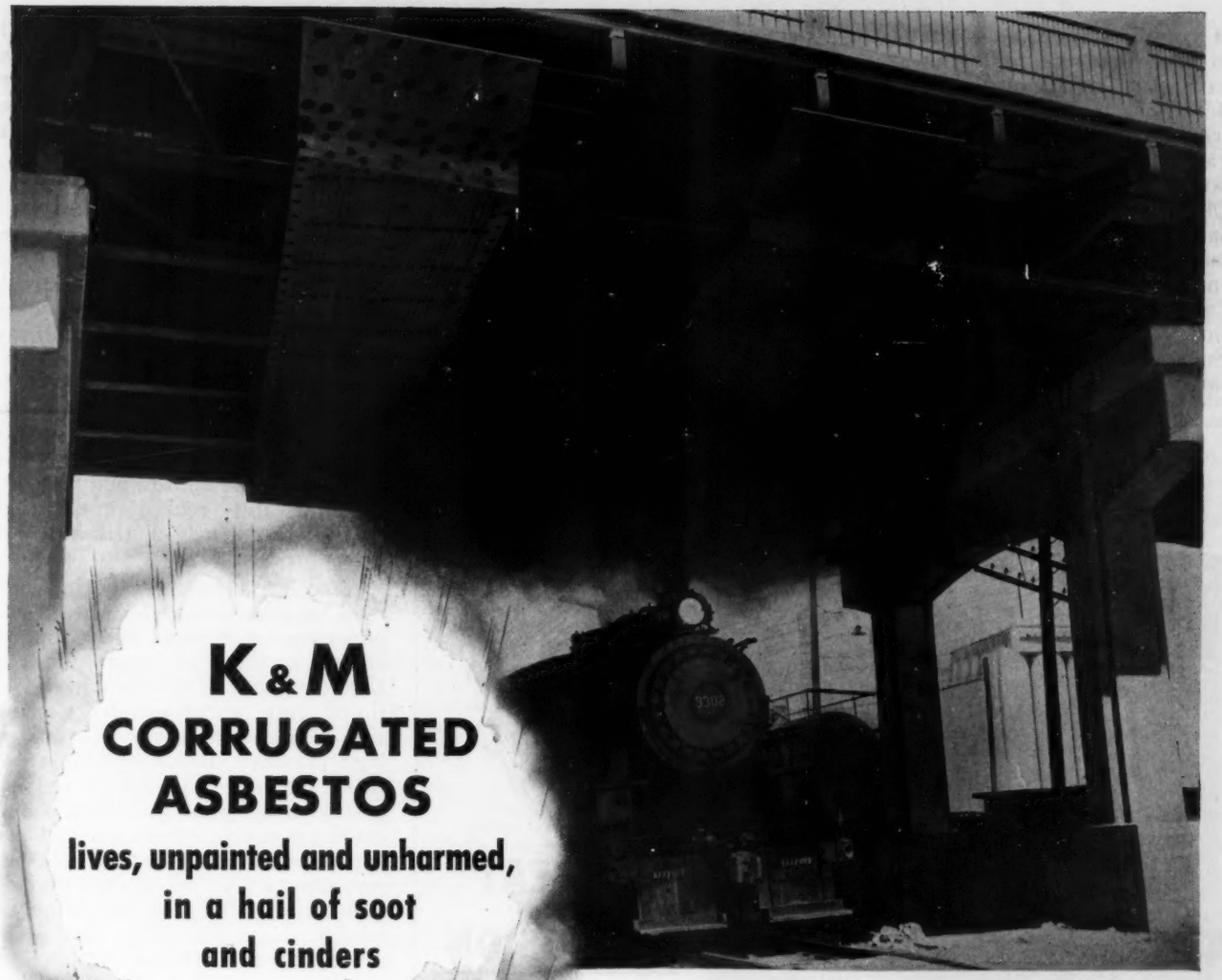


K&M CORRUGATED ASBESTOS

lives, unpainted and unharmed, in a hail of soot and cinders

Showing the blast plates of "Century" Corrugated after more than a year's service on the Minnesota Avenue Viaduct, Kansas City, Kansas. No paint has been used, no maintenance needed.

Can you think of any other sheet building material that each day could repel the fiery blasts from the stacks of nearly fifty locomotives —without even the protection of paint, and without a hint that painting or other maintenance will ever become necessary? Keasbey & Mattison "Century" Corrugated Asbestos is doing exactly that on the Minnesota Avenue Viaduct in Kansas City, Kansas.

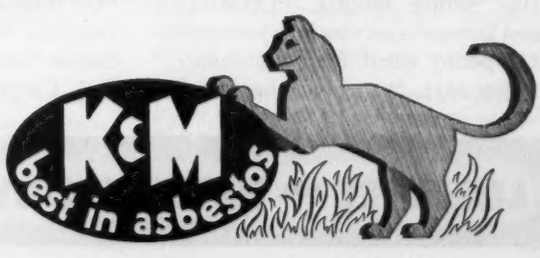
Installed more than a year ago, the blast plates made of K&M "Century" Corrugated protect the structural steel of the viaduct from the biting corrosion of locomotive smoke and soot. Inspection shows that their bare, unpainted surface is in perfectly sound condition . . . ready and able to deliver maintenance-free service indefinitely.

Here are conditions that test "Century" Corrugated Asbestos ruthlessly . . . and give conclusive evidence that "Century" Corrugated offers weather-resisting, fire-resisting, maintenance-free service for use on the roof and sidewalls of your own industrial buildings. Write Dept. 05 for complete catalogue information.

K & M *"Century"* CORRUGATED ASBESTOS

KEASBEY & MATTISON

COMPANY, AMBLER, PENNSYLVANIA



of commendation. It is gratfiying to note that the following states have part or all of the National Board of Fire Underwriters' standards in their liquefied petroleum gas safety codes: Minnesota, South Dakota, Nebraska, Kansas, Oklahoma, Texas, Arkansas, Alabama, Louisiana, Mississippi, Kentucky, Tennessee, Ohio, Michigan, Indiana, and New Mexico, with California now considering revisions of its existing safety code. Future efforts in the promotion of safety, particularly education of personnel and of new comers in the industry, is worthy of most serious consideration by those responsible for the management of this industry.

The Interstate Commere Commission is placing in effect January 7, 1941, revised regulations for the transportation of hazardous commodities in which are included for the first time specifications for the construction of fusion-welded high-pressure tank-car shells. This places on the approved list, tank cars recently constructed by fusion welding which have been operated on an experimental basis. This is an important change in tank car specifications permitting the use of the most modern methods in building this type of equipment.

The Interstate Commerce Commission issued regulations effective June 15, 1940, covering the transportation of liquefied petroleum gas by common and contract truck carriers in interstate commerce. With only minor modifications, the regulations of the Interstate Commerce Commission follow closely those safety practices long used by the industry, which is certainly a recognition of the high standards maintained and the splendid safety record experienced in the tank truck distribution of these products.

A recent survey of special railroad tank cars used for the transportation of butane and propane shows a total of approximately 1200 cars now in service with additional units under construction as this article is written. Because of high-pressure shells and insulation this type of equipment is considerably more expensive than is the ordinary gasoline tank car and the approximately 1200 units therefore represent a very substantial investment and a definite indication of confidence in the future of the industry by the owners.

This young industry can be proud of its fine record which enables rural and suburban American families to have the modern conveniences of gas cooking, water heating and refrigeration; which furnishes a highly refined fuel for large and small industrial plants and which has contributed so much to the comfort of travel in modern passenger trains. Continued success and progress in the future can be assured by proper attention to economics, by aggressive merchandising and by careful observance of established safety standards.

The No.1 way TO BEAT CORROSION

Line your vessels with low-cost, corrosion-resistant concrete!

THIS refinery vessel has a lining of Refractory Concrete that gives positive long-life protection against corrosion—at *low initial cost.*

Made with LUMNITE, this lining is your answer to lower maintenance costs. Refiners find it the simple, reliable and economical way to protect reaction chambers, fractionating columns, bubble towers, evaporators, saturators and other vessels against corrosive action even under pressure at high temperatures.

One refiner reports, "LUMNITE vessel linings in service four years without a penny spent for maintenance." Another says, "cracking chamber lining of LUMNITE in service for seven and a half years."

Refractory Concrete, made with LUMNITE and a corrosion-resistant aggregate, is easily shot on with a cement gun or placed by hand. It is ready for service almost as soon as placed, so that vessels go "on stream" with minimum delay. LUMNITE makes it easy to line or re-line new and old vessels, and simplifies repair work.

For detailed information, write for "Oil Refinery Manual." Address Atlas Lumnite Cement Company (United States Steel Corp. Subsidiary), Dept. R-7, Chrysler Bldg., New York City.

LUMNITE FOR REFRACTORY CONCRETE

Bareco Oil Company Changes Control

Control of the common stock of Bareco Oil Company, Tulsa, is being transferred to a group of individuals, headed by O. L. Cordell, president. The group will purchase the stock from Barnsdall Oil Company. George R. Hahn and H. V. Blaxter, Pittsburgh, have been added to the board. Other purchasers are Henry Oliver Rea and James C. Rea, also of Pittsburgh, and Edward B. Burling, Washington.

The properties include refining plants at Wichita, Kansas, Barnsdall, Oklahoma, and Corpus Christi, Texas.

[*Continued from Page 36*]

Unless sound economy suddenly must be scaled with a warped yardstick, oil is an industry of which government should be proud.

Somehow the plea of the President is not convincing. When there is no public clamor for legislation, when an industry has its industrial plant in harmony with a national crisis, when its personnel is loyal and patriotic, why and how does it get the call to come in and be measured for a suit of economic planning? Assumption and speculation provide the only answers.

Federal Commission

The legislation came out of the Department of the Interior as a proposal to set up a federal commission for certain control of oil production. It went before the public and industry for hearings. Both the industry and state officials opposed it, while the public gave it scant attention. Then it was rewritten and made applicable only to states without conservation laws or to states whose conservation is inadequate. In this form it went into a committee file, from which at the request of the President it will be drawn for further hearings.

The measure looks like an effort of Harold L. Ickes and others of his school of thought to gain a measure of nationalization, only control, of a private industry. The bristling Interior Department secretary never appears happy. Several years back he brought the threat of public utility status for the petroleum industry before the American Petroleum Institute.

More recently he has expressed preference for federal control for oil with the addition that oil under tideland waters should belong to his department as well as the Navy Department. That he wants more to do with oil is certain. He believes the states incompetent to deal with oil conservation. Since he wants control for the federal government, he must doubt that the industry is capable of conservation.

If his words and actions justify this conclusion, it must be admitted that he has support in high places. There are a few senators whose constituency deals rarely with lease and bonus money, who will support the proposal. The Attorney General has said that federal control looks like the answer to waste, with monopoly control the alternative.

It is a question which the industry should answer in unison. No doubt an effort will be made to array owners of small investment against ownership of large investment. Before men take sides on this, they best had look about and see how many small business concerns exist in an industry which comes under control of any branch of government. There are no small railways and no small utilities. Big capital is required to deal with government and the bigger the government the more capital must combine to match government.

Federal control is harsh however applied. It is no fertile ground for small business.

L. A. Gibbons, Los Angeles, general counsel of Union Oil Company, and Buell F. Jones, Chicago, counsel of Standard Oil Compapny (Indiana) have been added to the American Petroleum Industries Committee.

The Look Box

Refining Papers on Chemical Program

Manufacture of glycerine by chlorination of propylene was discussed by Dr. E. C. Williams, Shell Development Company at the meeting of the American Institute of Chemical Engineers, New Orleans, December 5 and 6. The process is on a semi-commercial basis and his observation was that the petroleum industry could provide the product in case of a need for war.

The operation of the Thermofor kiln for revivification of clay was the subject of T. P. Simpson, E. S. Nichols and J. W. Payne, Socony-Vacuum Oil Company, New York.

Distillation problems in refining was the subject of J. W. Packie, Standard Oil Development Company, and L. B. Bragg, Foster Wheeler Corporation, New York.

V. G. Skogan and M. C. Rogers, University of Minnesota, had a paper, "The Estimated Number of Stages Required in Liquid-Liquid Solvent Extraction of Lubricating Distillates."

Lubrication was the subject of J. O. Maloney and A. E. Schubert, Pennsylvania State College under the title, "The Rectangular Coordinate Methods as Applied to Solvent Extraction Design."

CONVENTIONS

FEB.	
17–20	**American Institute of Mining and Metallurgical Engineers, New York.**
24–25	**Liquefied Petroleum Gas Association, Annual Convention, Chicago.**
MAR.	
3– 7	**American Society for Testing Materials, Hotel Mayflower, Washington.**
APR.	
7–11	**American Chemical Society, St. Louis.**
16–18	**Western Petroleum Refiners Association, Arlington Hotel, Hot Springs, Arkansas.**
23–25	**Petroleum Industry Electrical Association, Mayo Hotel, Tulsa.**
23–25	**Natural Gasoline Association of America, Baker Hotel, Dallas.**
24–25	**National Petroleum Association, Cleveland Hotel, Cleveland.**
24–26	**Petroleum and Natural Gas Conference, State College, Pennsylvania.**
MAY	
5– 8	**American Gas Association, Natural Gas Section, Dallas.**
19–23	**American Petroleum Institute, Mid-Year Meeting, Mayo Hotel, Tulsa.**
JUNE	
23–27	**American Society for Testing Materials, Forty-Fourth Annual Meeting, Palmer House, Chicago.**

Aviation Gasoline Supply Is Ample

Ability of the petroleum industry to provide 100-octane aviation-grade gasoline for both defense and commerce is equal to any demand now indicated in the opinion of William S. Farish, president of Standard Oil Company (New Jersey) and chairman of the committee on defense policies of the American Petroleum Institute. His observation was made in a letter to executives of 15 large oil companies. Axtell J. Byles, Institute president, made the letter public and gave it this interpretation:

"The defense commission and the Army and Navy have only to provide adequate storage, order this gasoline and the petroleum industry will keep those tanks full."

Since the letter gives analysis what the industry can do, what it proposes to do and asks for guidance from government, it is quoted in full, as follows:

"I am writing each of you gentlemen because your company is known to us to be a producer of 100-octane gasoline.

"Recently Mr. J. Howard Pew, president of Sun Oil Company, raised the question with me as to the ability of the petroleum industry to produce 100-octane aviation gasoline today, and as to the probable quantity to be needed over the future by our government. He took up this matter with me because I am chairman of an Institute committee dealing with some defense problems—problems more particularly centered in the protection of refineries, storage, harbors, etc. in time of war. The question having been raised, it seemed to me advisable that some attempt be made to analyze the entire 100-octane situation from a supply-and-demand viewpoint so as to understand just what problems might be met in the future concerning this question.

"Our people have made an attempt to check the producing capacity of the industry, and they are in agreement that the industry today can produce slightly in excess of 4,000 barrels daily of hydro-codimer and will have completed by March 1, 1941, about 16,000 barrels a day of alkylate production. This gives slightly in excess of 20,000 barrels a day of blending agents available March 1.

"There are in addition some 4,500 to 5,000 barrels of alkylate and hydro-codimer capacity, construction of which is being considered by various companies.

"It is our estimate that this 20,000 barrels daily of blending agents will produce something like 35,000 barrels daily of 100-octane gasoline. This would be higher if the best combination of blending agents and available base stock could be attained.

"Apparently there is no danger of shortage of base stocks. Our estimates show available industry base stock now to be 46,200 barrels daily, of which only 20,000 would be required in combination with the blending agents mentioned above. Additional supplies of base stocks could be made available on relatively short notice.

"In addition to this current picture, it it our judgment that the supply of 20,000 barrels of blending agents daily could be doubled within 12 to 14 months at a cost of approximately $1,500 per barrel/day of alkylate capacity. In other words, an investment of about $30,000,000 on the part of the oil-refining

industry would double the supply. This in turn would approximately double the supply of 100-octane gasoline. All that is required to get this 100 percent increase in capacity is for someone to order and agree to buy the additional gasoline.

"To complete this picture I think we should note that 100-octane capacity as described above is based on the use of a limit of 3 cc. of lead per United States gallon. Although there is still some difference of opinion in technical circles, we are of the opinion that up to 4½ cc. of lead per gallon could be used safely if the emergency warranted. This use of 4½ cc. of lead would increase supplies about 30 percent as against using 3 cc. of lead.

"Another point that I think should be noted in connection with the supply side of the picture is that up to the fall of 1941 we will have an excess supply of 100-octane production in the United States. Obviously, this excess supply should be bought and stored as fast as available so that no productive capacity is lost during this period. It is hoped that the government will purchase such excess supplies as are available promptly to insure maximum production during this time.

"It is probably impossible to make an accurate estimate of government demand for 100-octane gasoline. From our own estimates and from what information there is available, I am sure the production capacity of the industry, if fully utilized, is capable of supplying more than the government demand during the year 1941 plus the commercial and export demand. I have not attempted to estimate demand beyond 1941. Obviously, reliable estimates are not available.

"In addition to the government demand, we estimate the commercial plus export demand will run about 10,000 to 12,000 barrels daily. All of the above figures refer to the use of 100-octane gasoline. We expect the demand for 90-92-octane to be met easily from the available base stock supply.

"There are perhaps other questions, the answers to which are not available. One might well be the accuracy of the demand estimate. More training planes may need 100-octane than is now assumed. Commercial needs for 100-octane may grow apace with the Army and Navy needs. Other things not now foreseeable may show the present calculations to be amiss.

"As I understand the situation, this story is clear and the facts are all in the hands of the Defense Commission. The responsibility for the accuracy of the demand side of this program is one that the industry cannot assume. The Defense Commission and the War and Navy Departments have been advised just what the industry can do and just what it will be doing in the natural course of things, and this should be the limit of the industry's responsibility. The responsibility for knowing what the demands of the government departments are going to be for high-octane gasoline must rest with these departments. As stated above, it is perfectly clear that greatly increased supplies of 100-octane can be had, provided someone contracts to buy the gasoline and the industry is given 12 to 14 months' time in which to build additional facilities.

"The industry has always met every demand made upon it, as evidenced by its record in the last war and in every emergency demand made upon it in peace-time. I am sure that in the present emergency we will meet any demand that may develop. All of us should be happy over the fact that our industry today constitutes no problem to the proper functioning of defense preparedness. There are no bottlenecks and there is no hesitation; we are ready to answer, fully and without delay, any call the government may make upon us."

Refiners Group Asks Distillate Proration

The Gulf Coast Refiners Association last week called for extension of Texas proration laws to production of distillate. A resolution charging "the entire scheme of proration" was being threatened by uncontrolled distillate production was adopted by the association last week for submission to both houses of the legislature, convening January 14.

"It is the opinion of this association that the production of petroleum and the derivatives of crude petroleum by recycling plants constitutes, in effect, crude oil produced under no restriction and used in direct competition with crude oil subject to proration, and is an important factor in the determination of allowables for wells now subject to proration," the resolution said.

"The entire scheme of proration of production of crude petroleum is threatened by uncontrolled production by recycling plants of petroleum and the derivatives of petroleum," it added.

The association asked "legislation which will place the production of petroleum and derivatives of petroleum and gas by recycling plants upon a ratable basis comparable to that for regulation of the production of crude petroleum subject to proration laws."

"It is the opinion of this association that there can be no good reason for making any distinction between the production of petroleum distillates or derivatives of petroleum and gas in liquid form when there exists only a difference as to mechanics of getting the liquid out of the ground, and this same liquid is in direct competition with prorated crude petroleum and derivatives."

Cole asks Continuation of Investigating Committee

Continuation of the petroleum subcommittee of the House Interstate and Foreign Commerce Committee until May 1, next, was provided in a resolution introduced and adopted by the House at the opening of the new Congress January 3.

The resolution followed a preliminary report by the committee in which additional time was asked to determine the defense position of the oil industry requested by President Roosevelt in November.

As the subcommittee has expended only about half of the $15,000 provided for its investigations, it was pointed out, the additional work now contemplated should not cost anything.

The report was brief, consisting of two paragraphs of explanation of the situation and the President's letter of November 29, in which he asked that consideration be given to the situation in the oil industry occasioned by world developments and our defense program.

"The vital need for petroleum in the national defense, the importance in com-

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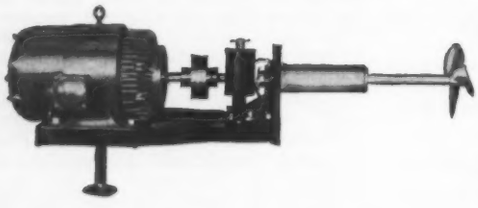

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merce and industry and the critical conditions in Europe and Asia confirm my belief in the urgent need of federal legislation to safeguard our petroleum supply through the prevention of waste and by the establishment and maintenance of sound economic conditions in the oil industry," President Roosevelt said at that time.

Cole explained that the subcommittee had prepared a "preliminary but very complete report" in addition to the voluminous hearings held during the past year and a half, but the President's letter prompted the group to decide that for the information of Congress "additional consideration should be given by the committee immediately to the question of petroleum in the national defense."

"Under these circumstances," he said, "the committee recommends that this report be accepted as preliminary to the final report to be filed with the next Congress as soon as completed."

Continuation of the subcommittee until May 1, next, was asked in a resolution introduced in the House at the opening of the new Congress January 3.

It was made clear that extension of the subcommittee's life was asked primarily in order that it might make the further study asked by the President, chiefly that members of the national defense advisory commission might have a chance to testify.

No definite plans have yet been made for the hearings, but it is expected they will be called sometime toward the end of this month or early in February. It was indicated that after relatively brief bearings, the subcommittee would close its investigation and prepare its report.

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Bureau Sees Heavy Demand for 1941; Sets January Figure

A sharp increase in imports, heavy withdrawals from stocks and increased domestic production will be required next year to meet the nation's demands for oil, including those of the defense program, the United States Bureau of Mines warned December 18.

Foreseeing an increase of not less than 8 percent in domestic demand in 1941 over that of this year, the bureau estimated that an increase of at least 10,000,000 barrels in imports, a decrease of similar size in stocks and an increase of two percent in daily average crude production will be required to care for the situation.

The bureau's monthly forecast set crude production for January at a daily average of 3,591,000 barrels, 31,000 barrels above the estimate for December and 2700 barrels higher than the actual demand in January, 1940, but emphasized that this figure represents a "minimum" and its estimates may have to be increased in succeeding months if the trend of demand proves greater than now foreseen.

The bureau reported that daily average crude production during the four weeks November 9 to December 7 was 3,573,000 barrels, and runs to stills were 3,505,000 barrels, while, during the period, domestic stocks decreased at a rate of 32,000 barrels a day, indicating a daily demand of 3,605,000 barrels.

Attempting to chart the course of demand for the coming quarter, the bureau explained that to do so "it is necessary to consider the probable demand for all oils during the coming year to secure the proper perspective."

Eight Percent Gain "Reasonable"

"An increase of 8 percent in the daily average domestic demand for all oils in 1941, including special defense requirements and stocks, seems a reasonable and conservative assumption, assuming no drastic changes in international relations," it said. "This would amount to an actual increase of about 102,000,000 barrels for the year. A further loss in exports might reduce this figure to a 6 percent increase in the total demand for all oils, a gain of about 87,000,000 barrels in 1941 over 1940.

"Crude production of about 3,700,000 barrels daily in 1940 will be in excess of demand as indicated by an estimated increase in the stocks of all oils (crude and refined) of about 40,000,000 barrels for the year. Consequently, the same rate of production in 1941, with no stock changes, would supply almost one-half of the increased demand for all oils (87,000,000) as estimated above. The remaining increase of 47,000,000 barrels in the demand for all oils might be met by stock decreases of 10,000,000, by increased imports of 10,000,000, and by a gain in crude-oil production of 27,000,000 barrels. This would indicate a daily average crude-oil production of 3,775,000 barrels in 1941, an increase of 2 percent over 1940.

"The balance of possible refined oil exports, imports and stock changes would indicate an increase in crude runs to stills of over 4 percent, or an average rate of nearly 3,700,000 barrels daily for 1941."

If demand should materially exceed these estimates, it was pointed out, a direct increase in both crude production

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and runs to stills would result, and refinery operations east of California might be close to capacity, particularly if the crude runs in the first quarter are at too low a level.

"The abnormally high demand in the first quarter of 1940 will reduce the rate of increase in demand for the same period in 1941 below the estimated average for the year," it was explained, "but the relative increase in subsequent quarters would be progressively greater.

January Figure is Minimum

"The bureau believes that its forecast of crude runs and demand for January represents a minimum, and that these figures may have to be increased in subsequent forecasts for February and March if the trend of demand proves greater than now seems reasonably probable.

"The current adjustment of unbalanced refined inventories would indicate the continuance of the yield trends as shown in actual October operations, namely, a relatively low gasoline yield, a normal distillate yield, and an increased residual yield.

"A sharp rise in the demand for residual-fuel oils is indicated as defense activities get into full production. Residual-fuel stocks east of California, although several million barrels above the abnormally low level of last year, appear to be inadequate. As indicated in the December forecast, this situation would require either greater runs than are necessary for other products, increased residual yields or larger imports.

Bureau of Mines Forecast of Crude Oil Demand for January

State	Forecast January 1941	Forecast December 1940
Texas	1,297,500	1,277,000
California	594,800	593,900
Oklahoma	439,000	422,600
Illinois	340,300	363,600
Louisiana	287,400	280,300
Kansas	191,000	188,400
New Mexico	100,000	100,600
Wyoming	73,900	74,500
Arkansas	66,100	66,100
Pennsylvania	48,000	47,900
Michigan	46,100	47,100
Indiana	20,000	15,500
Montana	19,000	19,700
Mississippi	15,200	13,900
Kentucky	14,800	13,900
New York	13,000	12,100
West Virginia	10,000	9,000
Ohio	9,000	8,000
Colorado	3,900	3,900
Nebraska	2,000	2,000
	3,591,000	3,560,000

"Stocks of finished and unfinished gasoline apparently will be about 82,000,000 barrels on December 31, 1940. A normal increase of at least 14,000,000 barrels seems unavoidable in the first quarter of 1941, so that a peak of 96,000,000 barrels is probable on March 31, 1941, as compared with almost 104,000,000 barrels at that same time in 1940. This stock position would represent a material improvement because of the expected increase of 6 to 7 percent in domestic motor fuel demand during 1941, and also because the figure will include an increase of several million barrels in essential aviation-gasoline stocks."

Explaining its forecast for January, the bureau said domestic demand for motor fuel for the month is estimated at 43,000,000 barrels, 6.5 percent more than the actual demand in January, 1940. The estimate for exports, based on forecasts by the principal exporters, is 1,900,000 barrels, 100,000 barrels above the estimate for December but 374,000 barrels under actual shipments in January of this year.

It was pointed out that stocks of finished and unfinished gasoline on October 31 were 79,185,000 barrels and, according to statistics of the American Petroleum Institute, they declined approximately 500,000 barrels during November, indicating an inventory of about 78,700,000 barrels at the end of that month. Although finished gasoline stocks increased more than 7,500,000 barrels during January, 1940, because of the heavy demand for heating oil due to the extremely cold weather, the bureau estimates an increase of only 6,300,000 barrels for the first month in 1941.

With benzol production and direct sales of natural gasoline estimated at 1,500,000 barrels, the indicated refinery production is placed at 49,700,000 barrels, which the bureau allocates among the various refinery districts as follows:

Allocation to Districts

East Coast, 6,680,000 barrels; Appalachian, 1,850,000; Indiana-Illinois, 10,690,000; Oklahoma, 2,670,000; Kansas-Missouri, 2,800,000; inland Texas, 3,360,000; Texas Gulf Coast, 11,600; Louisiana Gulf Coast, 1,280,000; inland Louisiana-Arkansas, 880,000; Rocky Mountain, 1,320,000, and California, 6,580,000.

Determining factors in the crude situation will be the estimate of 7.1 percent, or 3,520,000 barrels, of the total refinery production for natural gasoline to be blended at refineries, and the yield

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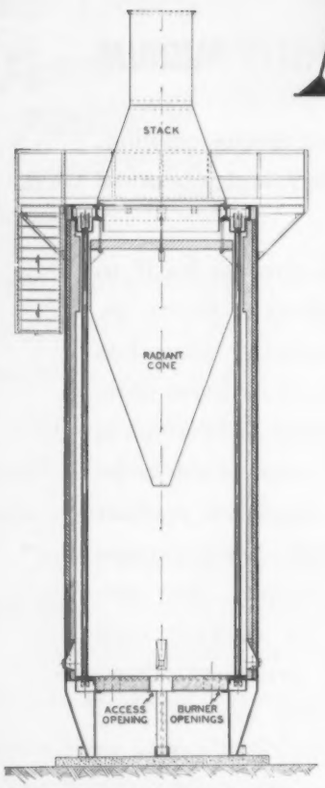

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of straight-run and cracked gasoline, estimated as 42.6 percent, which, applied to the production of 46,180,000 barrels, gives crude runs of 108,420,000 barrels, or 3,497,400 barrels a day.

The estimate for foreign crude run to stills has been raised 100,000 barrels to 3,700,000 barrels, which is 849,000 barrels higher than the actual for January, 1940, and crude exports are estimated at 3,900,000 barrels, the same as in the November and December forecasts. Crude to be used for fuel and losses is estimated at 2,700,000 barrels.

The total demand for domestic oil in January, as indicated by the estimates, is 111,320,000 barrels, or 3,591,000 barrels daily, allocated among the several producing states as shown by an accompanying table.

Defense Consumers Group Warns Against Price Rises

Indirectly warning the oil industry against any increases in prices that cannot adequately be defended, Miss Harriet Elliott, commissioner in charge of the Consumers Division of the National Defense Advisory Commission, declared January 2 that "recent rises in the price of domestic fuel oil are not the result of the defense program, and there is no justification for a further rise."

The primary cause of the price increase, Miss Elliott said, is increasing demand for fuel oil for home, office and apartment heating, "providing an opportunity" to producers and distributors to secure higher prices.

The division report declared that shortage of tankers to transport oil from the Gulf to New England ports does not explain the price rise, asserting that tanker and storage facilities are adequate to take care of existing demand and pointing out that operating costs of tankers have not risen; insurance rates have not risen but have been lowered in some instances, and although wage rates have increased slightly, they constitute no more than 15 percent of the total costs of tanker operations.

"Tanker tonnage transferred to the navy and to foreign registry represents only about 13 percent of the total tanker capacity," it was stated.

"Published charter rates for tankers have increased, but 90 percent of the oil moving from Gulf ports to the Atlantic seaboard is transported in tankers belonging to large oil companies which do not pay the published charter rates. Apparently there has been no important increase in the costs of operating these tankers."

However, it was added, should the situation in tanker facilities eventually become critical, there are sources from which added facilities may be made available. Now under construction, some near completion, are 56 new tankers representing a capacity of over 500,000 tons; certain of the ships transferred to foreign registry could be made available under the recall provisions included in their transfer, and some of these could be made available to independent oil companies so that active competition might be maintained.

"Stocks of fuel oil in the hands of refining companies at the end of October were larger than stocks held at the same time a year earlier," Miss Elliott said. "The possibility that consumers may make provisions for other forms of heating in new construction and replacement will tend to restrain any further

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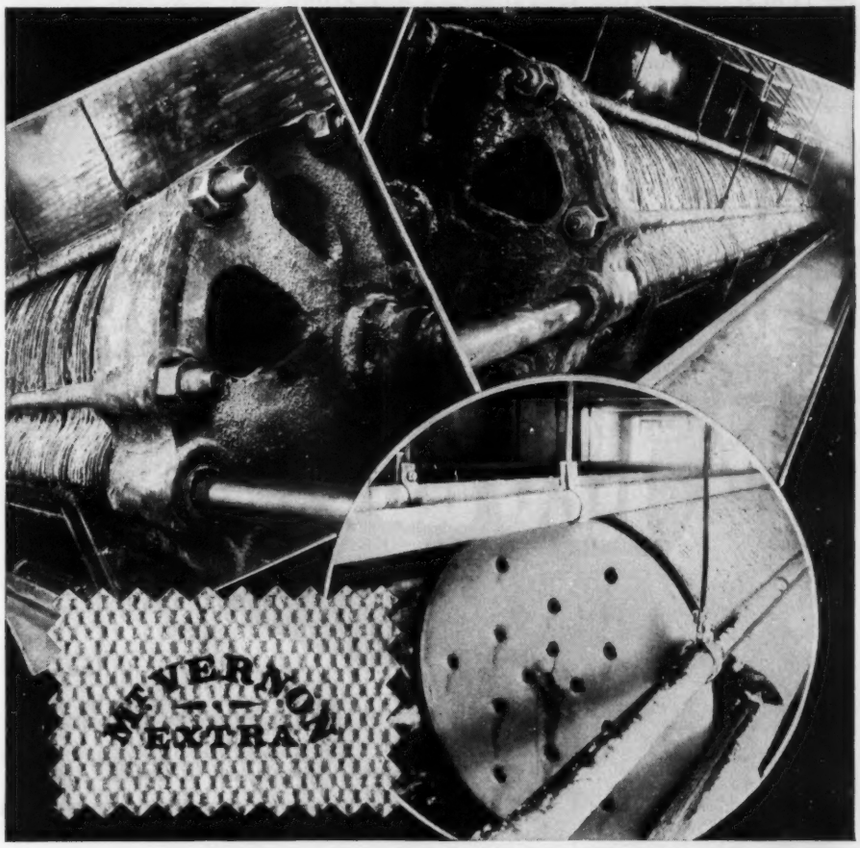

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rises in fuel oil prices, according to the study.

"The consumer division is continuing its study of the present fuel oil situation with the view of suggesting action to the defense commission, to the producers and distributors, and to consumers of fuel oil. Conferences may be held later with members of the industry."

The investigation was undertaken as a result of complaints following increases in the price of No. 2 fuel oil from $6.13 per 100 gallons on September 15 to $7 on December 15 in Boston, from $6.12 to $6.89 in New York, from $6.33 to $6.75 in Philadelphia, and from $6 to $6.75 in Baltimore.

Arnold Calls for Greater Vigilance Against Monopoly

Increased vigilance lest the national defense program be used for fostering monopoly was called for January 3 by Assistant Attorney General Thurman Arnold, in charge of the anti-trust division of the Department of Justice.

"Preparation for national defense inevitably opens the door for even greater concentration of industrial wealth and power," Arnold declared in his annual report to the attorney general. "It is well known that large-scale expenditures for military purposes are always accompanied by the danger of booming prices and by other dangers born of relaxed business standards and relaxed public vigilance. In these times, when all ramparts need to be watched, it is particularly urgent that a domestic rampart such as anti-trust enforcement be kept at full strength. The existing emergency is as much an emergency for our economic structure as for our external security."

Arnold made no specific reference to the broad suit filed last year against the oil industry in the District of Columbia Federal Court, but confined his report almost entirely to an exposition of the many responsibilities of his division, which enforces 31 acts in addition to those dealing with monopoly. He did explain, however, that about three years are required for handling an anti-trust case, the first year to investigation, the second to securing an appropriation and preparing the case, and the third for its trial.

"The second year is usually the most difficult because in anti-trust enforcement it is often necessary to prove an unlawful course of conduct by evidence of a series of hidden practices which, when pieced together, constitute a pattern of prohibited conduct," he commented. "Most of the evidence upon which an anti-trust case is built frequently must be sought in the files of the offending parties. And after 50 years of experience, the seasoned violators are no longer careless about the contents of their files."

Tax Division Report

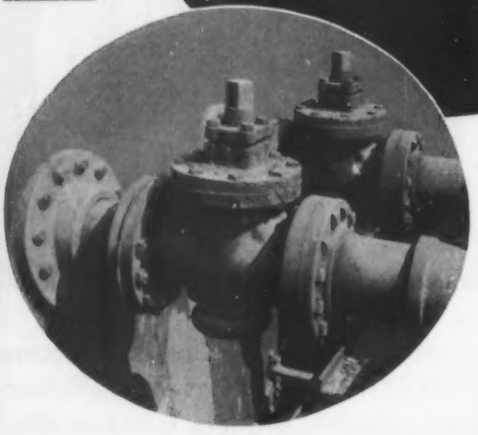
Two decisions of utmost importance in connection with depletion of oil and gas wells were rendered by the Supreme Court during the last fiscal year, it was emphasized by Assistant Attorney General Samuel O. Clark, Jr., in reporting upon activities of the tax division.

The decisions were rendered in the cases of the Wilshire Oil Company and the F.H.E. Oil Company.

"Under the revenue act of 1926 and subsequent acts," the report explained, "Congress permitted the deduction of depletion based upon a percentage of the gross and net income from the property. The allowance was 27½ percent of the gross income from the property during the taxable year, but the acts provide that the allowance shall not exceed 50 percent of the net income of the taxpayer from the property.

"Development expenses which the taxpayer had elected to deduct currently were deductible from the gross income in arriving at the net income from the property. The Supreme Court held that if such expenses were deducted in determining taxable net income, they should likewise be deducted in determining the net income upon which the depletion was to be based.

"The decisions are very important from a tax standpoint," Clark said, "because practically all oil companies exercised the election granted by the regulations and deducted such expenses currently. The effect of these decisions on the revenue is inestimable. These decisions are equally, if not more important in the field of administrative law. They hold that the treasury has power to change its regulations, at least prospectively, notwithstanding the re-enactment of the statute while the prior regulations were in effect."



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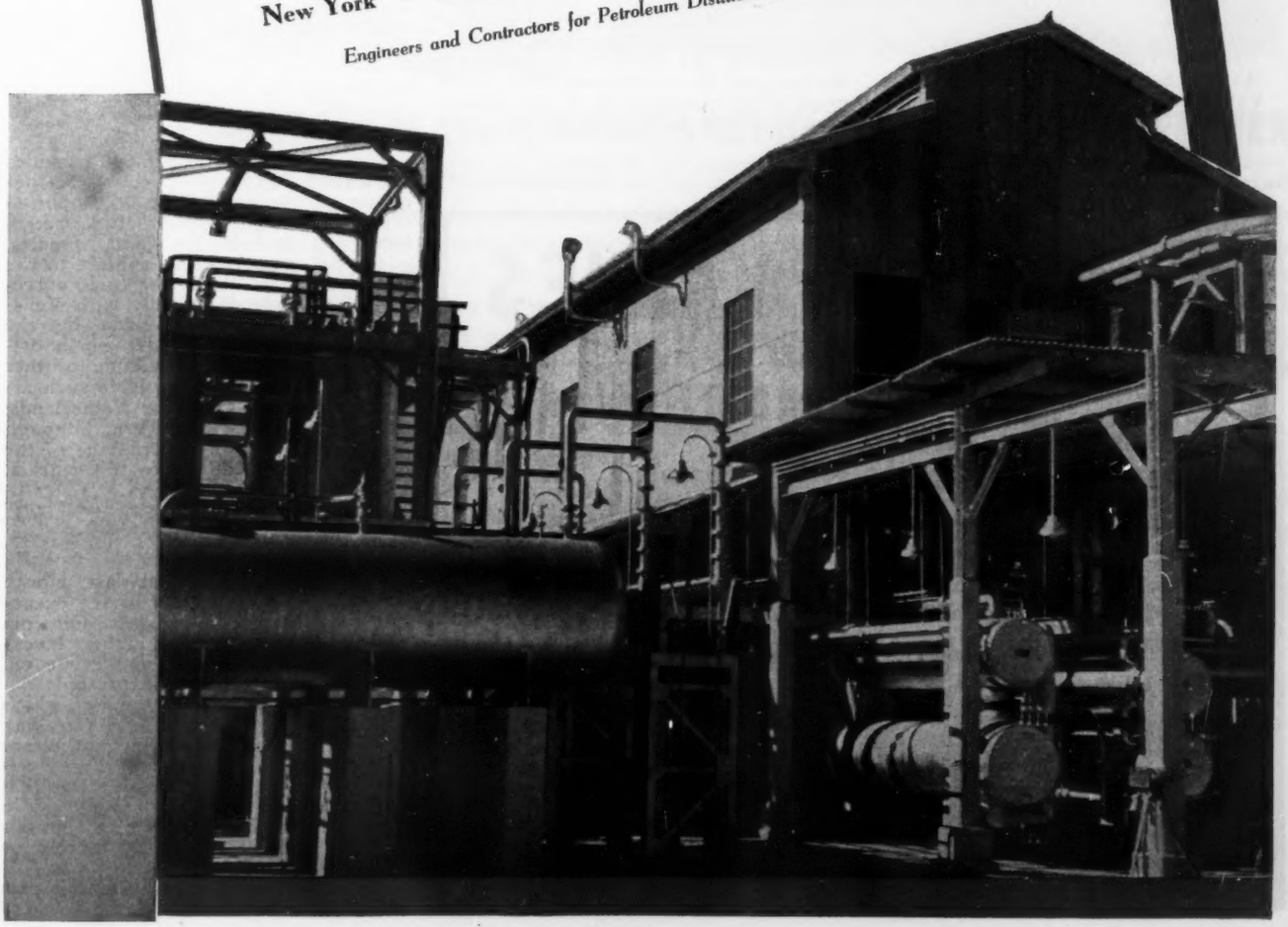


Fuels and Lubricants On S.A.E. Program

Two discussions on lubrication in relation to the internal combustion engine were on the program of the annual meeting of the Society of Automotive Engineers, Detroit, January 6 to 10.

"Engine Design Versus Engine Lubrication," was discussed by R. J. S. Pigott, Gulf Research and Development Company; "Lubrication of Severe Duty Diesel Engines," was presented by J. G. McNab, W. C. Winning, B. G. Baldwin and F. L. Miller, Standard Oil Development Company.

Midwest Power Conference Dates

The 1941 meeting of the Midwest Power Conference will be held April 9 and 10 at the Palmer House, Chicago. This conference is sponsored annually by Illinois Institute of Technology with the cooperation of seven other midwestern universities and colleges and the local sections of the Founder and other engineering societies. The conference is entering its fourth year under the present sponsorship.

The tentative program includes sessions on central station practice, stationary prime movers and plant auxiliaries, hydro power, electric power transmission and distribution, feedwater treatment, and industrial power plants. Among the proposed papers for the various sessions are the following:

Survey of Stationary Power Facilities from the Standpoint of Defense.

A Resume of Present Day Power Trends.

Forced Circulation in American Power Plant Practice.

Modern Steam Turbine Design.

Variable Speed Drives for Plant Auxiliaries.

Hydro Power and the National Emergency.

Re-establishment of Cable Communication.

Application of Recording Meters and Equipment.

Some Problems in Power System Stability.

Increasing Power Production with Present Boiler Facilities.

Interchange Contracts between Industrial Plants and Utilities.

Inquiries in regard to the conference may be addressed to either Stanton E. Winston, conference director, or Charles N. Nash, conference secretary, in care of Illinois Institute of Technology, 3300 Federal Street, Chicago, Illinois. It will be remembered that Armour Institute of Technology and Lewis Institute were recently merged to form what is now known as Illinois Institute of Technology.

Mexico Imports Under Low Rate Upped for 1941

Mexico's share of oil imported under terms of the Venezuelan reciprocal trade agreement will be increased by one-third for 1941 under a reallocation of quotas announced by the State Department December 31 in publishing a proclamation issued by President Roosevelt December 28.

To provide for expansion of cut-rate imports from Mexico, it was revealed, the proportion granted Venezuela and Colombia will be decreased. The Netherlands also is scheduled for a larger proportion of the total than it enjoyed during the year just ended.

The State Department explained that under the terms of the President's proclamation, the shares of the total imports of petroleum and fuel oil entitled to the reduction in import tax are allocated among the countries of supply on the basis of the proportions of the total imports for consumption in the United States supplied during the calendar year 1939.

As a result, the proportion granted Venezuela will be reduced from 71.9 to 70.4 percent; that for the Netherlands, including its overseas territory, will be increased from 20.3 to 21.3 percent; that for Colombia will be reduced from 4 to 3.2 percent, and that for "other foreign countries," which means Mexico, will be increased from 3.8 to 5.1 percent.

The President's proclamation did not set the quantity of oil which may be imported during the coming year at the reduced excise-tax rate. Under the agreement, the reduction is to be granted on imports not in excess of 5 percent of the total quantity of crude petroleum processed in refineries in the continental United States during the calendar year 1940. That figure will not be available for some weeks, but the Bureau of Mines production report for October indicates that the amount which may be imported will exceed that of 1940, on the basis of crude runs to stills which, for the ten months ended with October, amounted to 1,079,216,000 barrels in 1940 compared with 1,027,089,000 barrels in 1939.

1940 Quota

The quota for 1940 was placed at 61,892,000 barrels, equivalent to 2,599,464,000 gallons, as being 5 percent of the total of 1,237,840,000 barrels processed in United States refineries during 1939. On the basis of the amount refined up to the end of last October, it would appear that the quota for 1941 will be in the neighborhood of 64,500,000 barrels. The 1940 quota figures were announced March 22, last, and it will probably be some time in March before the allocation for the current year is calculated.

On the basis of a total quota of 64,500,000 barrels, Mexico would be enabled to ship into the United States approximately 3,289,500 barrels by taking the full 5.1 percent allocated "other countries."

Lower Tax

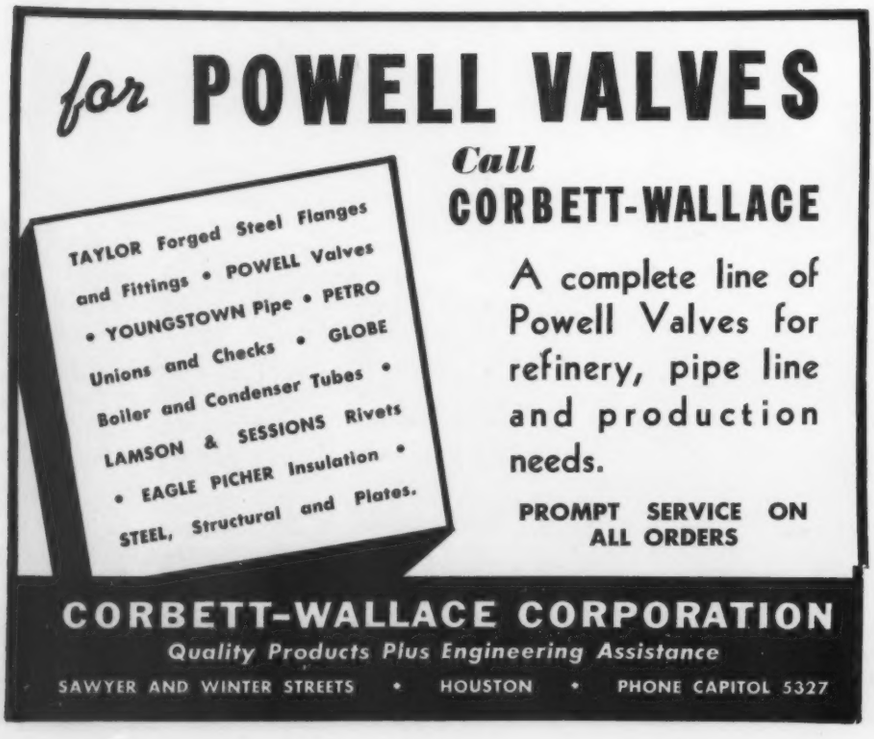
The Venezuelan agreement provides for a reduction from ½- to ¼-cent per gallon in the excise tax on imported crude petroleum, topped crude petroleum and fuel oil on quota imports, additional imports being subject to the full rate of tax. While the trade agreement was made specifically with Venezuela, all concessions made by the United States were, under our most-favored-nation policy, available to other countries with which we have such arrangements, including the Netherlands, Colombia, Mexico and Peru, although the last has not taken advantage of the opportunity to ship oil to this market.

Sinclair Favors Increased Stocks

In a public statement last month H. F. Sinclair, chairman of the executive committee of Consolidated Oil Corporation, recommended higher inventories of both gasoline and crude oil. His opinions were thus expressed:

"I do not share the opinion which has been often expressed over a long period of time that these inventories are excessive," he said. "We are using about 3,000,000 barrels of crude oil a day east of the Rocky Mountains. Crude oil in storage in this area at this time approximates a total of 227,000,000 barrels, or only about 75 days' supply.

"It is a mistake to think of this raw material as being piled up somewhere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and about to engulf us. Many millions of barrels are not really available at all. If the industry is to continue to function, the pipe lines must always be full; hundreds of refineries must have working stocks on hand; millions of barrels must always be in transit on the water. So we really haven't 75 days' supply—probably less than half of that. I believe we are going to have a greatly increased demand for petroleum products, and we therefore need more oil in storage. Crude oil stocks are too small rather than too large. I also think that those who are pinching down production according to some outgrown formula are going to find that they have missed their mark and underestimated our needs. We need the insurance of an ample supply of crude. We only know we have such a supply when it is in steel storage above ground and located where it is needed.

"I feel even more strongly about gasoline stocks," Sinclair added. "Anxiety is expressed because we have a few million barrels more than someone estimated several years ago was the ideal figure. We should have more because consumption is greater. I know of no excessive stocks in any area. It seems to me that less than two months' supply of gasoline is very little for an industry as vital as ours to all industry, to defense and to the necessities and well-being of the whole country. No other industry similarly situated would think of operating on so narrow a margin of safety. And as noted with respect to crude, the stocks of gasoline are not really available in any such amount as would be indicated by the figures. Gasoline must be stored in hundreds of terminals, thousands of bulk stations and several hundred thousand service stations; in pipe lines and otherwise in transit. The greater part of it must always be there if 1,500,000 barrels of gasoline are to be available every day.

"I look for a considerable increase in consumption in 1941. There are more cars and there will be more use of them. We don't want any more 'gasless Sundays' or rationing. The defense program, when it is in full motion, will lead to much larger demand. The latest estimate we have of 1941 consumption made by Dr. A. G. White, of the Bureau of Mines, is that the increase will be from 8 to 9 percent. If this estimate is correct, there will be a period of months beginning probably in the second quarter when the increase in consumption is sure to be more than 10 percent. This means that we shall need an additional 150,000 barrels of gasoline every day (or, roughly, 350,000 additional barrels of crude daily), over and above what we are now using."

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Look at the illustration at the left. Here is a reproduction of a "PYREX" Broad Red Line Gauge Glass as you would see it in your boiler room from directly in front. Hold this picture at arm's length; you can't deny its visibility. Place it across the room, fifty, even a hundred feet away. As long as you can see it, you can see the liquid level.

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Baker Heads Humble Refining Activity

Hines H. Baker has been appointed head of refining operations of Humble Oil & Refining Company, Houston. His duties also include direction of sales activities. His appointment followed the death of Stuart A. Giraud, who died December 22, 1940.

Baker has been with the Company since 1919, when he became a member of the legal staff. He became a member of the board of directors in 1937.

Giraud had been with Humble Oil & Refining Company since 1916, first as auditor and later as assistant to the president. In 1932 he took over sales activity and in 1936 refining operations were added to his responsibilities.

Robinson Named To Defense Post

Philip M. Robinson, manager of research and chief engineer of the Pennzoil Company, Oil City, has been named an assistant to Dr. Robert E. Wilson, petroleum section, Raw Materials Division, Council of National Defense.

He has been with The Pennzoil Company since graduation from the University of Michigan in 1928. He became assistant superintendent of plant number 2 at Oil City in 1931 and later became manager of research.

Asphalt for Military Roads

Road improvements in a national defense program were stressed as one of the few expenditures that will benefit a nation after an emergency has passed at the thirteenth National Asphalt Conference in Dallas, December 9 to 13. Patrick J. Hurley, former Secretary of War, laid stress on this prospect in opening the conference.

The Conference consists of meetings of two organizations, the Asphalt Institute and the Association of Asphalt Paving Technologists.

Have you noticed how many leaders in their field like *HANCOCK* rely on Lebanon to supply steel castings of assured structural integrity?

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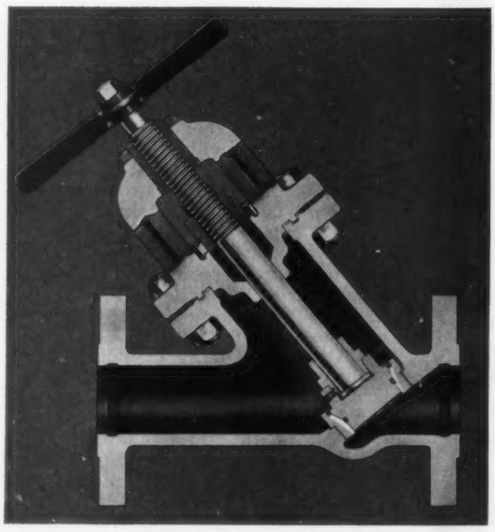

The steel castings which Hancock purchases from the Lebanon Steel Foundry are used on 300, 600 and 1500 pound globe and angle valves for service up to 950° F. and on the new Hancock Blow-off valves.

The Circle L mark on the steel castings of your valves, pumps and other equipment is an assurance of structural soundness and integrity. You may buy cheaper steel castings but you can't buy better.

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Original American Licensee George Fischer (Swiss Chamotte) Method

Lebanon STAINLESS AND SPECIAL ALLOY **Steel Castings**

Allowables for January Close to Market Demand

The program of allowables for January promises to hold the nation's production of crude oil fairly well in line with market demand.

If the allowables were rigidly adhered to, there would be almost complete balance between production and market requirements, as estimated by the United States Bureau of Mines. The eight prorated states, which supply about 84 percent of the country's requirements, have January allowables 11,522 barrels under the aggregate market demand for the oils from those states; while unprorated Illinois in the past month produced 9250 barrels a day less than the amount estimated as current market demand for Illinois crude.

Actual production does conform closely with the state allowables in most of the states, with exception of California. That state during the past month overproduced by 40,000 barrels daily the allowable that prevailed under the operators' voluntary proration program. And similar overproduction there may be expected in January. That excess would run up to approximately 1,250,000 barrels for the whole month, and it would constitute the bulk of the excess indicated for the United States.

The January allowable program calls for almost the same degree of curtailment as did the December schedules. But after a part of December had elapsed, the Texas Railroad Commission in a special order provided for an extra day of shutdowns of Texas fields, with the result that the nation's output conformed very closely with demand for the month as a whole, as evidenced by the fact crude stocks did not increase. In the absence of such unscheduled shutdowns, a somewhat less perfect balancing of production and demand is to be expected for January.

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Ark-La-Tex Division Has Question Program

The January meeting of the Ark-La-Tex Division, Western Petroleum Refiners Association, devoted its January program to the answering of questions. The program was held in the Washington-Youree Hotel, Shreveport, January 10.

Previous to the meeting members sent in more than 50 questions, which were used as the basis for the session. A. W. Trusty, chief chemist, Cities Service Oil Company, Shreveport, had charge of the meeting.

Technical Manual To Be Enlarged

Directors of the Natural Gasoline Supply Men's Association have decided to increase the new material section of the Technical Manual from 16 to 32 pages. The book will have printing of 3000 copies, 1000 more than in 1937. Details of distribution also were considered.

Directors also considered entertainment for the 1941 meting of the Natural Gasoline Association of America, Baker Hotel, Dallas, April 23, 24 and 25 and G. B. Lane, chairman of the membership committee, also was named chairman of the entertainment committee. He will select members from among concerns which have offices or headquarters in Dallas.

George H. Taber Dies in Pittsburgh

George H. Taber, retired vice president of Gulf Oil Corporation, died at his home in Pittsburgh December 10. He was in charge of refining for the Company over a long period and his connection with this phase of the petroleum industry began in 1882. Much of the development of methods and equipment for the removal of wax from lubricating oil was due to his work.

Taber, a native of Fairhaven, Massachusetts, entered petroleum refining in 1882 at the plant of the Queens County Oil Company, Brooklyn. While there he introduced the plate-and-frame filter press for de-waxing chilled distillates. Later he went to the Eclipse works of The Atlantic Refining Company, where he introduced the centrifugal process for removing wax from cylinder stock-naphtha mixtures. Later he was superintendent of the Philadelphia plant of The Atlantic Refining Company. Here he made application of American fuller's earth in percolation.

In 1905 he became general manager of Gluf Refining Company and later was chosen vice president in charge of manufacturing. He had a part in formation of the Mellon Institute, an institution to which he devoted much time in later years.

Frederick R. Speed, automotive engineer of the Pennsylvania Grade Crude Oil Association, has established headquarters in Detroit, 416 Stephenson building.

PLANT ACTIVITIES

Polymerization at Casper: The Texas Company has completed construction of a catalytic polymerization unit at its Casper (Wyoming) refinery. It has a maximum throughput of 1,400,000 feet of gas daily, and was designed by Universal Oil Products Company.

Expansion for Shamrock: Additional storage, new boiler house, pipe lines and other equipment are included in a $15,000 expansion program undertaken by Shamrock Oil & Gas Corporation at its plant at McKee, Moore County, Texas.

Odessa Plant Expansion: Cities Service Oil Company is expending $175,000 for gas purification and a dehydrating unit at its cracking plant 14 miles north of Odessa, Texas. The equipment is being used to process tail gas for West Texas Gas Company, serving Midland and Odessa.

Canadian Aviation-Grade: British American Oil Company last month was completing improvements to its plant at Calgary, Alberta, Canada, to process aviation-grade gasoline from Turner Valley crude. Flying schools of the Royal Canadian Air Force in the prairie provinces have created a demand for the gasoline.

Louisiana Recycling: The Louisiana Conservation Department on January 9 will hear application of Stanolind Oil & Gas Company for construction of a $500,000 recycling plant in the South Jennings field, Jefferson Davis Parish. Construction of the project, if approved, will start shortly.

More Shell Storage: Shell Oil Company has announced immediate construction of 35,000,000 gallons of additional storage on the Atlantic Coast for gasoline and fuel oil. The new tanks will be located in the New York and Boston areas.

New Grapeland Plant: Fourth recyling plant for the Grapeland field, on the south end of the East Texas Woodbine belt, has been authorized by Geier Bros., Inc., and F. B. Jackson, Jr., Dallas producing partnership. Contract was awarded to the Hudson Engineering Company, Houston, for completion of a 53,000,000-cubic-foot daily capacity plant by mid-April, 1941. John L. Hill, formerly head of the gasoline department of the Continental Oil Company, is chief engineer for the partnership, which will drill between six and 10 wells to the 6000-foot gas-distillate sand prior to completion of the plant. The partnership has acquired farm-out leases, aggregating 3000 acres within and adjacent to the proved area, and recently purchased J. C. Cook et al's Masters-Shell 83-acre lease, with a completed well.

Phillips in South America: Argentina has contracted with Phillips Petroleum Company for use of the latter's refining processes and patents. Engineers of Phillips Petroleum Company will cooperate with Argentinian refineries in installing a process for making high-grade aviation gasoline.

Solvent Extraction: Shell Oil Company has begun construction of a solvent extraction unit at its Wood River, Illinois plant. The equipment will provide first extraction of high solvency naphthas and odorless cleaning solvents from Mid-Continent oils. The cost is $550,000, which is in addition to the $10,000,000 construction and expansion program completed at the Wood River refinery last year.

Pipe Line: First deliveries through a part of the gasoline line of Southeastern Pipe Line Company were started early in January. The line is now complete from Port St. Joe, Florida to Brainbridge, Georgia. The project is to carry northward 450 miles into Tennessee. It is owned jointly by Gulf Refining Company and Pure Oil Company.

Synthetic Rubber: Shell Oil Company is considering construction of a synthetic rubber plant, which will be constructed at its Deer Park plant, near Houston.

Underground: Construction of a complete refining plant underground is under contemplation in England. The project is part of the effort to make industry immune from bombing. The project is calculated to turn out 30,000 barrels of petroleum products daily. Part of the output will be aviation grade gasoline.

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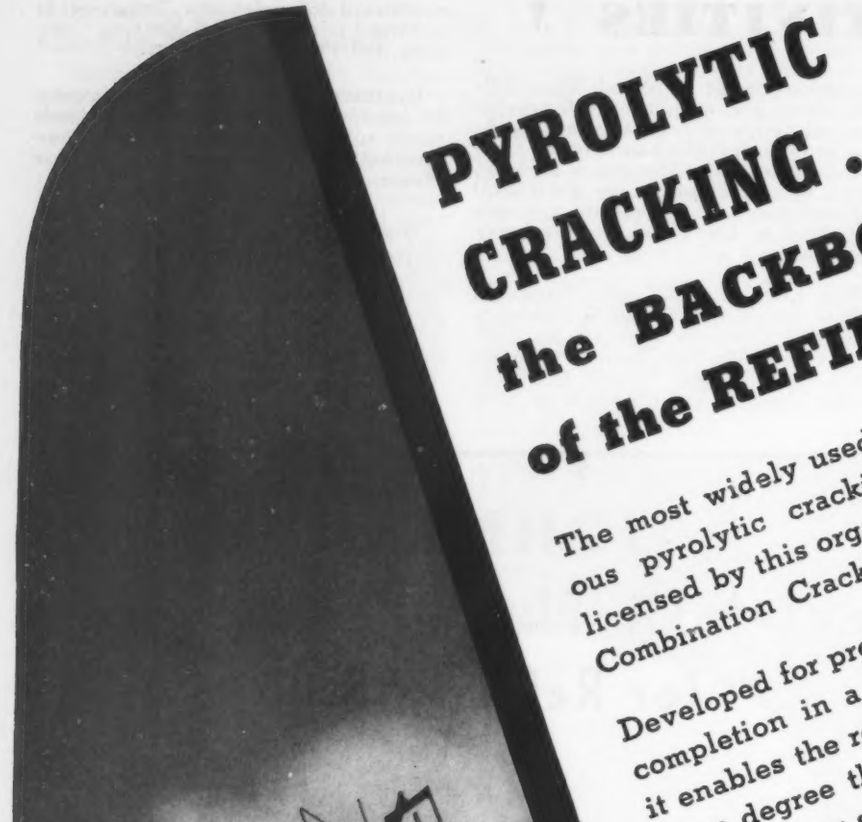

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SCIENCE AND TECHNOLOGY

Abstracts prepared in co-operation with the

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by

THE LESLIE LABORATORIES

Traver Road, Ann Arbor, Mich.

under the supervision of

DR. E. H. LESLIE and DR. H. B. COATS

The abstracts here presented are selected from the current literature of science and technology to afford reference to fundamental information not easily available to all readers. Abstracts of articles appearing in readily obtainable trade journals are not included. Photostat copies of original articles will be supplied at cost by the Leslie Laboratories. Complete or limited bibliographies covering special topics by title, by abstracts, or in complete manuscript, will also be prepared and furnished at reasonable cost by the Laboratories.

Fundamental Physical and Chemical Data

The Vapor Pressures of Some Organic Compounds. I., J. M. STUCKEY AND J. H. SAYLOR, *Jour. Amer. Chem. Soc.* **62** (1940) pp. 2922-5.

The vapor pressures of the xylenes, ethylbenzene, mesitylene, the chlorotoluenes, o-bromotoluene, m-bromotoluene, cyclohexane and methyl amyl keytone were measured at temperatures in the range 4° to 75°C. The data were fitted to suitable equations by the method of least squares. The literature of the vapor pressure of these various substances is reviewed, and the results of the investigation compared with previous results as reported in the literature.

The Pressure-Volume-Temperature Relation of n-Hexane and of 2-Methylpentane, E. A. KELSO WITH W. A. FELSING, *Jour. Amer. Chem. Soc.* **62** (1940) pp. 3132-5.

The authors note that the increasing utilization of petroleum hydrocarbons for many purposes demands a more extended knowledge of the properties of the individual hydrocarbons. One of the objects of the investigation reported was to determine the compressibilities of the hexanes. The compressibilities of liquid n-hexane and 2-methylpentane were determined at 25°C. intervals from 100 to 225°. The pressure-volume-temperature relations for gaseous n-hexane and 2-methylpentane have been determined at different molar volumes at 250 and 275°C. The data are presented in some detail in tabular form.

The Viscous Flow of Large Molecules, W. KAUZMANN AND H. EYRING, *Jour. Am. Chem Soc.* **62** (1940) pp. 3113-25.

The statistical mechanical rate equation is utilized to ascertain the mechanism of the flow of large molecules. It is shown that as hydrocarbon chains increase in length, they do not flow as a single unit, but tend to flow as segments which average roughly 20 atoms in length. This movement by segments of 20 to 40 atoms is generally characteristic of large molecules. The viscosities of longer hydrocarbons are larger than would be expected from the simple concept of holes as recently applied to the problem of viscosity. This effect is also shown in the recently reported proportionality of viscosity to $e^{aZ^{1/2}}$, where Z is the length of the chain for long-chain molecules. The latter relationship is shown to arise from the requirement that the random motion of segments of a large molecule must be coordinated in order that the molecule as a whole can move in the direction of flow. The treatment of non-Newtonian and plastic flow in terms of the rate equation is outlined and the results discussed qualitatively. The significance of the findings to the problems of dielectric relaxation and of rate processes involving large molecules is indicated.

The Viscosity of Monolayers: A Test of the Canal Viscosimeter, G. C. NUTTING AND W. D. HARKINS, *Jour. Amer. Chem. Soc.* **62** (1940) pp. 3155-61.

Experimental and theoretical studies of the rate of flow of monolayers through surface slits or canals have been made by several investigators. In the work presented in this paper the principal object was to determine what type of canal gives the best results. The canal viscosimeter and experimental methods are described. The canal regarded as most satisfactory was made from glass plates with lightly paraffined edges. The top edges of the plates were at the surface level and the sides were extended considerably below. Data are given for stearic acid, pentadecyl alcohol, hexadecyl alcohol, heptadecyl alcohol, and octadecyl alcohol. It is believed that the principal usefulness of the canal viscosimeter may be in the standardization of other surface viscosimeters.

Combustion of Methane: Displacements of Mixtures Giving Maximum Flame Velocities, A. R. T. DENUES WITH W. J. HUFF, *Jour. Amer. Chem. Soc.* **62** (1940) pp. 3045-7.

Summarized data are presented as a system of relations between flame velocities and the contents of methane in mixture with a given atmosphere, the oxygen content of which atmosphere is treated as a variable parameter. An extrapolated maximum flame velocity of 320 cm. per second for the combustion of methane in pure oxygen is in fair agreement with the value of 333 reported by Jahn. In common with previous results by various methods, the results of the investigation showed relatively small displacements for methane. Data show the effects of the oxygen content of the atmospheres used for the combustion of methane on flame velocities and on displacements of mixtures giving flame velocities. A new regularity between these displacements in the combustion of methane and the parameter cited has been adduced that contrasts with earlier indications for methane and complements relations derived by the writers from published data on other gases.

Dielectric Properties of Organic Compounds, S. O. MORGAN AND W. A. YAGER, *Ind. & Eng. Chem.* **32** (1940) pp. 1519-28.

The dielectric constants of polar liquids should be directly derivable from their chemical structure according to simple dielectric theory. In the instance of many liquids, the observed values differ greatly from those thus calculated. It is shown that these departures may be due to association or interaction, causing the molecules to act as associated pairs or aggregates in which the net electric moment is low because dipoles are so directed as to oppose one another. Such differences may also be caused by the effect of internal friction

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1 1/4"	6	20'
1 1/2"	12	20' to 21' 1 1/2"
1 1/2"	8	16' 2 1/2" to 20'
2"	8	20'
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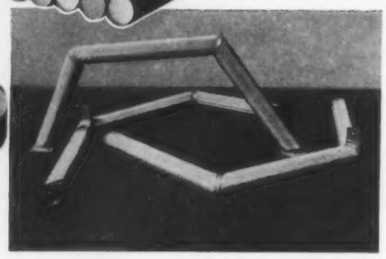

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or viscosity in restricting the motion of dipoles or to solidification which may entirely prevent motion. In the solid state where, on the basis of simple theory, no rotation can be expected and consequently low dielectric constants would be the result, it is shown that there are many cases of high dielectric constant. The geometry of the molecule is the determining factor in permitting rotation of molecules and high dielectric constant in the solid state. The more nearly the molecules approach a simple geometric form such as a sphere, circle, or rod, the more likelihood there is that they will be able to rotate.

Raman Spectra of Acetylenes. III. Five Monosubstituted and Four Disubstituted Acetylenes, F. F. CLEVELAND AND M. J. MURRAY, *Jour. Amer. Chem. Soc.* **62** (1940) pp. 3185-8.

Raman displacements, estimated intensities, and depolarization factors are reported for: 3-methyl-1-butyn-3-ol, 3-methyl-1-octyn-3-ol, 3-methyl-3-ethoxy-1-butyne, 3-methyl-3-acetoxy-1-butyne, 1-ethynylcohexanol, 2, 5-dimethyl-3-hexyne-2, 5-diol, 6, 9-dimethyl-7-tetradecyne-6, 9-diol, 6-dodecyne, and 1-phenyl-2-iodoethyne. Tentative assignments were made for certain of the observed frequencies.

Chemical Compositions and Reactions

The Reaction of Hydrogen Atoms with Butane, E. W. R. STEACIE AND E. A. BROWN, *J. Chem. Phys.* **8** (1940) pp. 734-8.

The reaction of hydrogen atoms as produced by the Wood-Bonhoeffer method, with butane was investigated in the temperature range 35° to 250°C. The activation energy was found to be 9 ± 1.5 kg.-cal. The products at low temperatures were solely methane; at high temperatures methane was also formed. Reaction mechanisms are postulated and presented for the primary and secondary processes.

Synthesis and Properties of Mono-Normal-Alkylbenzenes, Part I—Methods for the Alkylation of Benzene, G. SHEN AND C. E. WOOD, *Jour. Inst. Petr.* **26** (1940) pp. 475-87.

The principal available methods for preparing alkyl benzenes are critically reviewed. Seven methods are considered in detail—namely (1) Fittig's synthesis; (2) condensation of alkyl halides with benzene; (3) condensation of olefines with benzene; (4) condensation of alcohols with benzene; (5) interaction of inorganic and organic ester with benzene; (6) Grignard synthesis; and (7) hydrogenation of alkyl aryl ketones. Certain complicated reactions difficult of explanation on a logical basis and which lead to contradictory conclusions can be explained by, and are in agreement with, the fundamental ideas of activation and addition of an addend after cleavage in accordance with Markownikoff's rule. The first six methods are considered unsuited with regard to yield and purity of product. The hydrogenation of alkyl aryl ketones prepared by the Friedel and Crafts' reaction i.e., the acylation of benzene, appears to be the best method for obtaining the large quantities of hydrocarbons required for the determination of cetane numbers. This process is on the whole simple, does not involve rearrangement of alkyl groups, and is unaccompanied by side reactions. Neither does it involve a too-elaborate organic technique. Palladium is the best catalyst for effecting the hydrogenation. Considering the various chemical methods of reduction, the Clemmensen's method is to be preferred.

Isomerization Accompanying Alkylation. III. The Alkylation of Benzene with Neopentyl Chloride and Neopentyl Alcohol, H. PINES, L. SCHMERLING AND V. N. IPATIEFF, *Jour. Amer. Chem. Soc.* **62** (1940) pp. 2901-2.

The alkylation of benzene with neopentyl alcohol gives t-amyl-benzene in 30 percent yield when sulfuric acid is used as catalyst, and neopentyl benzene in 9 percent yield when aluminum chloride is used as catalyst. Neopentyl chloride and benzene react in the presence of aluminum chloride to form 2-methyl-3-phenyl-butane in 24 percent yield.

The Alkylation of Benzene with d-s-Butyl Alcohol, C. C. PRICE AND M. LUND, *Jour. Amer. Chem. Soc.* **62** (1940) pp. 3105-7.

The purpose of the investigation was to determine the stereochemical course for alkylation of the Friedel-Crafts type involving reactions at the asymmetric carbon atom. The boron fluoride and aluminum chloride cata-

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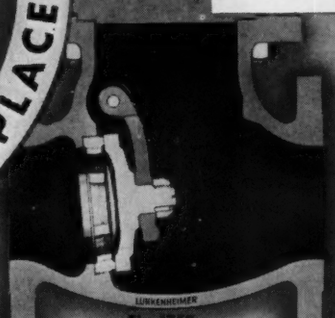

Fig. 1759
150 lb. S. P., 230 lb. W. O. G.
Steel Swing Check

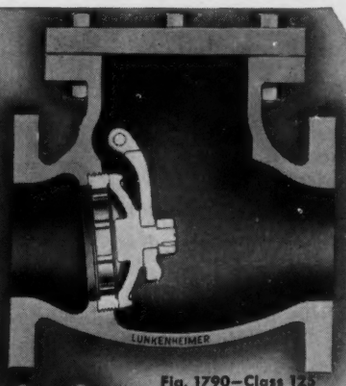

Fig. 1790—Class 125
125 lb. S. P., 200 lb. W. O. G.
I. B. B. M. Swing Check

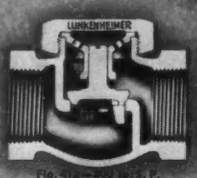

Fig. 418—200 lb. S. P.
Bronze Lift Check

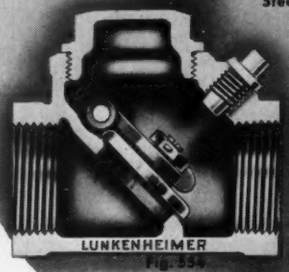

Fig. 554
200 lb. S. P., 400 lb. W. O. G.
Bronze Swing Check

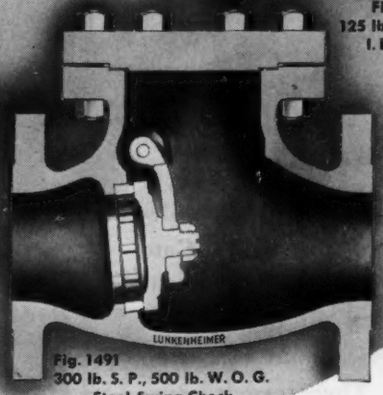

Fig. 1491
300 lb. S. P., 500 lb. W. O. G.
Steel Swing Check

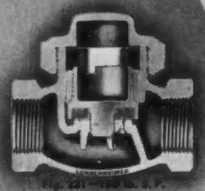

Fig. 221—150 lb. S. P.
Bronze "M-M-D" Lift Check
Non-Metallic Disc

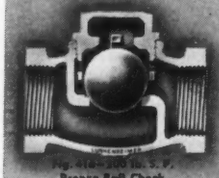

Fig. 414—200 lb. S. P.
Bronze Ball Check

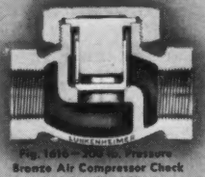

Fig. 1616—300 lb. Pressure
Bronze Air Compressor Check
Stainless Steel Disc

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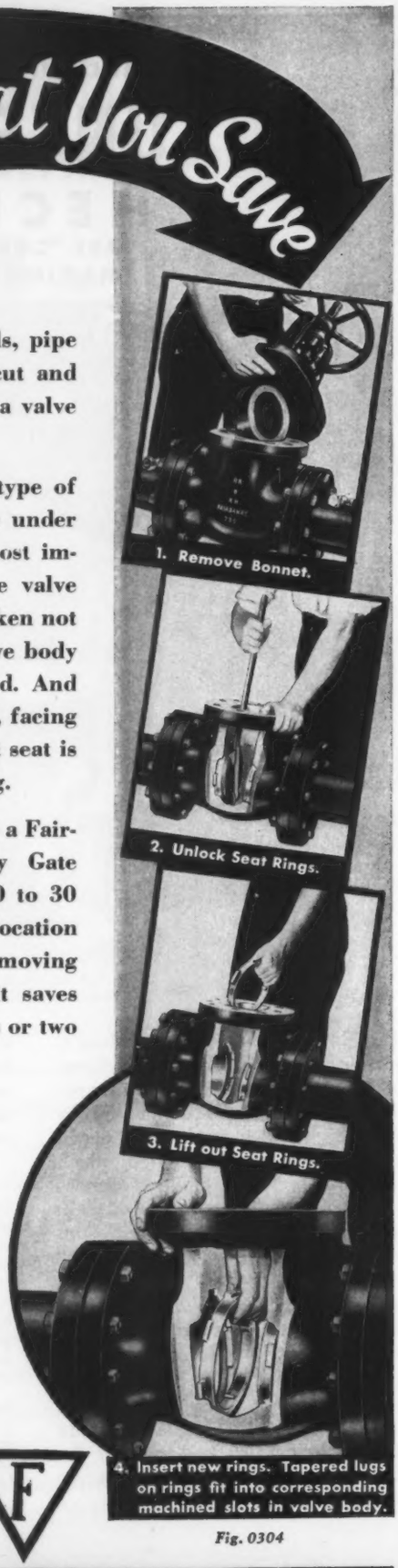
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2. Unlock Seat Rings.
3. Lift out Seat Rings.
4. Insert new rings. Tapered lugs on rings fit into corresponding machined slots in valve body.

Fig. 0304

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Valve illustrated is Fig. 0304

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lyzed alkylations of benzene with s-butyl alcohol were chosen, since, in each case, the reaction has been reported to proceed without isomerization of the alkyl group. It was found that the alkylation of benzene with d-s-butyl alcohol using boron fluoride as a catalyst yielded s-butylbenzene that was levo-rotatory. With aluminum chloride as the catalyst the product was racemic.

Manufacture: Processes and Plant

Nonboiling Heat-Transfer Coefficients in Annuli, A. S. FOUST AND G. A. CHRISTIAN, *Trans. Am. Inst. Chem. Engrs.* **36** (1940) pp. 541-54.

Investigation was made of the coefficients of heat transfer to water in annuli. The source of heat was condensing steam. The water receiving the heat was not permitted to boil. Several annular arrangements were made by combining 3 sizes of copper tubing and 4 sizes of iron pipes. The results could be expressed fairly accurately by using the quantity $0.04\ D_2/D_1$ (the ratio of the boundary diameters of the annulus) instead of the constant 0.0225 heretofore recommended for use in the Dittus-Boelter equation; Nusselt's equivalent diameter was also used. No great difference was noted whether the equivalent diameter was evaluated according to the conventional formula of fluid flow or according to Nusselt. When the conventional equivalent diameter is used, the numerical coefficient becomes $0.032\ D_2/D_1$.

Transmission of Heat to Boiling Liquids, T. H. INSINGER, JR., AND H. BLISS, *Trans. Am. Inst. Chem. Engrs.* **36** (1940) pp. 491-516.

Based on a careful study of prior investigations an apparatus was designed and operated with particular attention to accuracy of temperature and heat-flow measurements. Using this apparatus individual heat-transfer coefficients from a vertical chromium-plated tube to boiling liquids were determined. The liquids included water, aqueous solutions of a wetting agent and of sugar, carbon tetrachloride and isopropanol at atmospheric pressure. A few measurements were made for heat transfer to water at pressures below atmosphere. It was found that time is not an important variable when contamination is not present, but that liquid properties, heat flow densities and pressure are important. These facts, combined with the fact that diameter is not an important variable led to the formulation of the following correlation equation: $\log Y = 0.363 + 0.923 \log X - 0.047 (\log X)^2$ where $Y = h(pvo)^{0.5}/(CkpL^2\sqrt{r^3J^2g})^{0.5} \times 10^{10}$ and $X = (Q/(A\theta pL\sqrt{r^3Jg}) \times 10^{10}$. This equation fits the data taken at atmospheric pressure to within $\pm$ 20 percent. A more complicated but more accurate correlation is also presented. A simple correction for pressure, namely that h is proportional to $p^{0.4}$, suffices to correct values calculated by the above equation to pressures other than, but close to, 1 atmosphere.

Dropwise and Film Condensation of Steam, F. L. SHEA, JR., AND N. W. KRASE, *Trans. Am. Inst. Chem. Engrs.* **36** (1940) pp. 463-90.

The film coefficients for the dropwise and film condensation of steam were measured on a vertical plate condenser 23 inches long. Use of an improved method of measuring plate temperatures and heat flow gave dropwise coefficients with a maximum error of about 20 percent and an average deviation from mean values of approximately 10 percent. Under film-forming conditions the maximum error was 5 percent and the average deviation less than 2 percent. It was found that the Nusselt equation accurately predicts the change in coefficient with length for film condensation over the range studied. Calculated values are about 10 percent low for very short plates and 25 percent low when the length is 23 inches.

Heat-Transfer Coefficients in Glass Exchangers, A. S. FOUST AND T. J. THOMPSON, *Trans. Am. Inst. Chem. Engrs.* **36** (1940) pp. 555-78.

Results are presented for heat-transfer measurements in double-pipe exchangers. The inner pipes were made of Pyrex 1 inch and 2 inches in diameter. The water film coefficients under non-boiling conditions can be computed from the Dittus-Boelter equation with an increased numerical coefficient for calculation of the annulus film. The data indicates that the resistance of the steam film is small compared to the water film, even under conditions such that a large amount of condensate accumulates. A nomograph is given of coefficients for dehumidification of wet air. Air velocities from 13 to 135 feet per second, and moisture contents from 10 to 60 percent are covered. The cooling water was at an entering temperature of 50 to 95°F., and flowed at

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rates of 0.3 to 3.3 feet per second. Overall coefficients ranged from 13 to 92 B.t.u./hr./sq. ft./°F. The mass transfer rates corresponding to these coefficients correlate consistently 25 percent below the results of Colburn and Hougen for a vertical tube, which tube was shorter than the 4-pass exchangers used in this investigation. Under a surprising number of conditions, the condensing film coefficients are high enough so that the water film is the controlling resistance. Evidence indicating that the thermal conductivity of Pyrex borosilicate glass is higher than values that have been published is discussed.

Solutizer—A New Principle Applied to Gasoline Sweetening, L. E. BORDER, *Chem. & Met. Eng.* **47** (1940) pp. 776-8.

For several years it has been known that Shell Oil Company was working on a process for sweetening gasoline by extracting the mercaptans with an organic solutizer. The first treating plant employing this process was erected by Shell Oil Company at its Wood River, Illinois, refinery and placed in operation early in 1940. This unit, which treats 15,000 barrels per day, has operated without interruption since that time, and the predicted profitability which was founded on a complete laboratory study and two years of pilot plant operation has been most satisfactorily realized. A flow sheet of the plant is given. The treating solution employed is six normal in potassium hydroxide and three normal in potassium isobutyrate. With a solution to gasoline ratio of 1.5:10, the treatment reduces mercaptan sulphur from 0.10 percent by weight to 0.0004 percent by weight, and effects an increase in octane number of 0.5 to 0.7 units. The tetraethyl lead requirement is reduced 50-60 percent. The saving in tetraethyl lead combined with low operating costs have resulted in reducing the finishing costs for this gasoline by approximately 5 cents per barrel, as compared to the conventional combined treatment with caustic soda and doctor solution. The unit requires the services of one part-time operator. A bibliography of published articles with reference to the process is included.

Products: Properties and Utilization

Mineral Oil as a Wool Lubricant. Method for Promoting Removal of Mineral Oil from Wool by Emulsification, J. B. SPEAKMAN AND T. S. WANG, *J. Soc. Dyers & Col.* **56** (1940) pp. 259-61.

85:15 to 80:20 mineral oil-oleic acid mixtures are less easily scoured from wool by an alkaline agent than mineral oil oleyl-alcohol mixtures. This is because the soap formed from the oleic acid is effective in reducing the oil-water interfacial tension. Mineral oil-oleic acid mixtures are easily removed, however, by a neutral detergent such as sodium cetyl sulphate. It is considered that mixtures of a water-white mineral oil with a suitable saturated long-chain fatty acid or oleic acid + an antioxidant should be satisfactory as wool lubricants.

Wear Phenomena in Lubricated Metal Surfaces, A. S. T. THOMSON AND R. LOGAN, *J. Roy. Tech. Coll.* **4** (1940) pp. 696-704.

Wear curves for brass on steel, when various lubricants are used, indicate upper and lower critical pressures between which wear is small. After running between these pressures, the wear remains small when the pressure is reduced below the lower limit. It was found that addition of 0.5 percent of oleic acid to a mineral oil lubricant reduces the lower and increases the upper critical pressure. It was found, however, that colloidal graphite additions have little effect on the upper limit.

Wear-Load Characteristic of the Four-ball Test with Various Lubricants, R. SCHNURMANN, *Engr.* **149** (1940) pp. 567-8.

The general assumption of the existence of a "breakdown load" characteristic of gear lubricants, and of the belief of "seizure" being associated with a welding of bearing surfaces, are not supported by experiments with the 4-ball test. It is true that wear-load characteristics are an aid in the selection of gear lubricants. The dielectric strength of lubricants is related to their lubricating properties, and should be considered in relationship to the oxidation-susceptibility of the oil.

Friction and Temperature as Criteria for Safe Operation of Journal Bearings, S. A. MCKEE, *U. S. Bur. Standard J. Res.* **24** (1940) pp. 491-508.

One of the principal difficulties in the science of journal-bearing lubrication is that

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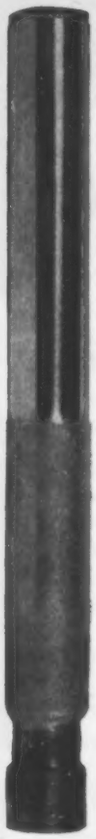

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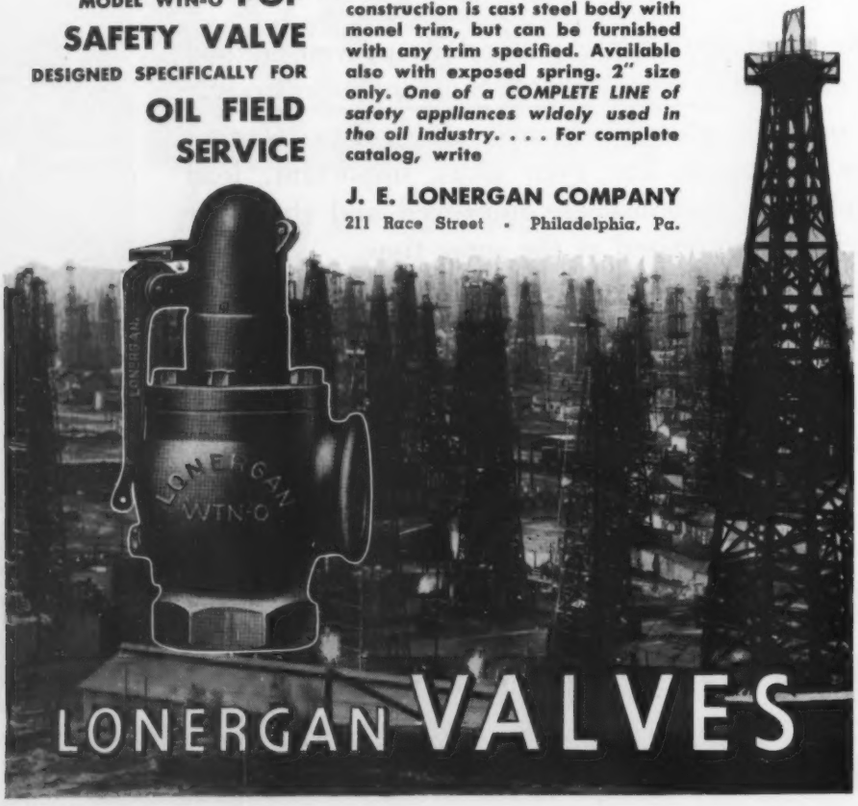

of applying the results of experimental studies to problems involving the performance of bearings in actual service. The author describes a method of applying friction and heat-dissipation data to the determination of the load-carrying capacity of a journal bearing operating with a lubricant of known characteristics. It is necessary: (1) that the bearing shall always operate in the region of stable lubrication, and (2) that it's operating temperature shall not exceed a limiting value. An equation for thermal equilibrium gives the relationship between the thermodynamic and hydrodynamic factors pertaining to journal-bearing lubrication. From this equation pressure-speed curves representing the limits for safe operation can be obtained by consideration of permissible values for temperature rise and the operating variable $\frac{ZN}{P}$ An example is given in which the method is applied to data experimentally in the laboratory with bearings and lubricants typical of some automotive installations. The method can also be applied to the calculation of the effect on load-carrying capacity of the bearing of changes in viscosity and in temperature and heat-dissipation characteristics. The practical application of the method to the case of automotive engine bearings is considered.

Electrical Insulating Oils and Jellies, E. E. HALLS, *Ind. Chem.,* October (1940) pp. 293-7.

Oils have been employed in the electrical industry on account of their dielectric strength and maintenance of this strength under damp conditions. They are used as impregnants, as in paper-covered cables, as coolants, in oil-filled transformers and switches, and for heat-transfer purposes, as in electrically-heated tanks, kettles and ovens. The criteria of chemical inertness, stability in storage or service, freedom from moisture, capacity and cooling properties, electric properties, physical properties, fire hazard, and resistance to low temperature, are all briefly considered. Petroleum oils are compared with oils of animal and vegetable origin, and with resin oils. The testing of oils for the various properties involved is briefly considered, and the results of typical laboratory tests of transformer oils and light electrical oils are given. Typical characteristics of high-temperature oils for electric immersion heaters are also given.

Electrical Insulating Oil Deterioration, J. C. BALSBAUGH, A. H. HOWELL, AND A. G. ASSAF, *Ind. & Eng. Chem.* **32** (1940) pp. 1497-1510.

Data presented in the paper were obtained in a long-term program of research on electrical insulating oil deterioration, which until September 1, 1939, was in cooperation with the Committee on Insulating Oils and Saturants, Utilities Co-ordinated Research Inc., Association of Edison Illuminating Companies. Since September 1, 1939, it has been carried on in cooperation with a committee sponsored by the Engineering Foundation and the American Institute of Electrical Engineers. The electrical and oxidation stability of two series of related samples of electrical insulating oils were studied. One series represented the products of several solvent-refining treatments and finishing treatments. The other series comprised oils of varying degrees of aromaticities, one of the samples being aromatic-free. Deterioration of the oils was effected by oxidation in the presence of paper and copper in an improved deteriorating system. The results show that the electrical and oxidation stabilities of an oil are differently affected by the initial chemical constitution and by the refining of an oil. The electrical loss as a function of oxidation time or oxygen absorbed may start with a rapid increase to a relatively high value, followed by an equally rapid decrease to a relatively low value with further absorption of oxygen, after which the loss again increases with continued oxidation. The paper contains much detailed information, with a detailed presentation of the results in graphical form.

Electrical Stability of Oil-Impregnated Paper, C. E. TRAUTMAN AND W. N. ARNQUIST, *Ind. & Eng. Chem.* **12** (1940) pp. 1535-9.

Refined petroleum oils have been widely used as impregnants for paper to produce composite electrical insulation in industrial applications such as high-voltage capacitors and underground cables. For such applications the insulation must have a sufficiently high dielectric strength to prevent electrical failure and also a relatively low power factor to limit the generation of heat. For oils derived by various refining treatments from one Texas Coastal oil, the power factor stability and high voltage life of the oil-impregnated paper were found to be related to specific dispersion and other properties reflecting the composition of the oil. Some results on other oils suggest that these correlations are not general. In this connection it is assumed that

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beneficial or detrimental substances are present in the oils in amounts too small to be detected by the tests reflecting the composition of the oil. The addition of a small amount of an antioxidant to the refined oils was found to improve markedly the power factor stability of the impregnated insulation. The results of the work are discussed at some length, and are presented in tabular and in graphical form.

Liquid Dielectrics, J. D. PIPER, C. C. SMITH, N. A. KERSTEIN, AND A. G. FLEIGER, *Ind. & Chem.* **32** (1940) pp. 1510-18.

Various compounds, selected to represent types of sparingly soluble oxidation products such as may be formed by the service degradation of insulating oils, were added to liquid paraffin in such concentrations that the systems appeared homogeneous at the higher temperatures employed and heterogeneous at the lower temperatures. The 60-cycle power factor and dielectric constant, and the direct-current conductivity of the systems were measured at several temperatures as the systems were cooled. At temperatures well above the transition temperatures, all the systems had lower factors and conductivities. At temperatures at which the systems appeared to be heterogeneous, those in which the suspended phase consisted of droplets of formic acid, moist acetic acid, ethyl alcohol, and phenol had power factors that were much higher than could be accounted for by Wagner's model of a heterogeneous dielectric. The power factor and conductivity of systems in which the suspended phase consisted of crystalline particles—namely, the systems containing palmitic acid, a-hydroxy-isobutyric acid, 10-hydroxystearic acid, cerotic acid, carnauba wax, laurone, and cholesterol—did not increase as the systems became heterogeneous. The power factor of systems containing cetyl alcohol, ceryl alcohol, and octadecyl alcohol increased markedly, however, as the systems became heterogeneous. The data are presented in considerable detail in tabular and graphical form.

Modifications in Combustion Micromethod for Carbon and Hydrogen, G. L. ROYER, A. R. NORTON, AND O. E. SUNDBERG, *Ind. & Eng. Chem.,* Anal. Ed. **12** (1940) pp. 688-90.

An apparatus and procedure are described for the determination of carbon and hydrogen, which, it is stated, are simpler than any previously described. Use is made of one-rate automatic combustion, ground-glass joints for connecting the absorption tubes, weighing of oxygen-filled absorption tubes, simplification of the combustion tube filling, elimination of the preheater, elimination of the wiping of the absorption tubes, and shorter intervals for the weighing of the absorption tubes. The procedure is applicable to routine industrial work. The apparatus is described in some detail, and typical results are given.

Determination of Acidity of Fuel and Lubricating Oils, M. B. RANDS, *New Zealand J. Sci. Tech.* **21, B.** (1940) pp. 267-72.

Potentiometric and indicator methods of determining acidity are discussed. A modified I.P.T. method for total acidity is described, in which phenolphthalein is replaced by a mixed indicator consisting of equal volume of 1 percent phenolphthalein in ethyl alcohol and of alkali-blue 6B 3 percent in ethyl alcohol. Titrations are in the usual manner, but a white tile is used as a stirrer. This is about 6 inches long and 1 inch wide and is of the same curvature across its breadth as the titration beaker. When the convex side of the tile is pressed against the side of the breaker the indicator color can be clearly seen. A color change with one drop of 0.1 N-KOH is readily detected even with the darkest oils. Some further slight refinements in the I.P.T. method for inorganic acidity are suggested.

Determination of Copper in Mineral Oils, A. G. ASSAF AND W. C. HOLLIBAUGH, *Ind. & Eng. Chem.,* Anal. Ed. **12** (1940) pp. 695-7.

A method is described for the measurement of traces of copper in mineral oils, particularly oxidized mineral oils. Methods described by otners are briefly reviewed, and difficulties in their use indicated. The authors' procedure is one of extractive titration with diphenylthiocarbazone. The method involves the oxidation of the deteriorated oil with a mixture of nitric, sulfuric, and perchloric acids, and evaporating the colorless solution almost to dryness. The residue is dissolved in redistilled water, the pH adjusted, and the solution finally titrated with a standardized solution of diphenylthiocarbazone in carbon tetrachloride.

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Browning Manufacturing's Gripbelt

Employing synthetic gums and free of rubber, the belt is described as resistant to many acids, alkalies and other chemicals. It is designed for use at continuous temperatures of 150 degrees F., or peak temperatures of 200 degrees F.

The line includes A to E sections, with the A-section units in pitch length of 27 to 129 inches, and E-section units in stock pitch lengths of 183.1 to 360 inches. Other sizes may be obtained on specification.

Motor

WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY

A line of open-type sleeve-bearing squirrel-cage induction motors, designed for general purpose drive applications, have been announced by Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pennsylvania.

Designated Type CS, they are available in ratings from ½- to 5-horsepower, at speeds from 875 to 3600 revolutions per minute, for operation on 110, 220, 440 and 550 volts, 2- and 3-phase AC.

Rigid complete-cast frames are designed to maintain constant air-gap between stator and rotor. Frame improvements include sealed sleeve bearings with a combination vestibule and felt washer seal, and a larger oil reservoir capacity. Oil filter cups may be inserted on either side of the motor.

Wire insulation is designed to give maximum dielectric strength, toughness and flexibility. Combination slot cells with reinforced cuffs are provided to protect windings from abrasion, and coil ends are taped for reinforcement against strains of full voltage starting.

Appearance has been improved by elimination of sharp corners and projections to give a rounded contour. Castings are buffed to produce a smooth, even surface. Finish is a light machine-tool gray.

Drum Handlers

LEWIS-SHEPARD SALES CORPORATION

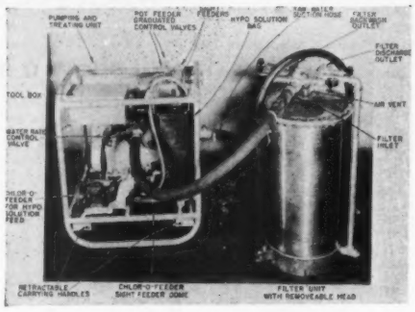
A tool to facilitate handling of barrels and drums, designated barrel and drum tipper, has been announced by Lewis-Shepard Sales Corporation, 245 Walnut Street, Watertown, Massachusetts.

The device consists of a handle with an adjustable pronged collar that permits the tipper to fit all types of drums and large- or small-bilged barrels. It is designed to make safe the job of tipping barrels from a horizontal to vertical position, or the reverse. A long handle is designed to increase leverage so that less effort is required to handle a barrel or drum.

Water Purifier

% PROPORTIONEERS, INC. %

A portable water-purification plant that may be placed in a truck and carried to the job with tools and supplies has been announced by % Proportioneers, Inc. %, 9 Codding Street, Providence, Rhode Island. It is designated



Proportioneers' Pur-O-Pumper

Pur-O-Pumper, weighs 750 pounds and occupies a space 4 x 6 x 4 feet.

The plant consists of a gasoline-engine-driven centrifugal pump, chlorinating and chemical-feeding equipment mounted on a pipe framework. A monel-metal filter to separate out turbid particles is mounted separately.

In operation, the Pur-O-Pumper is located near a stream, with the suction hose placed in the stream. When the engine is started, water from the stream is treated with coagulant chemicals, soda ash and alum, and chlorine for sterilization as it is pumped into the filter. The filter, which has a bed of sand and gravel, separates out turbid particles. The rate of flow of pure water depends upon turbidity of the raw water, and with 150 parts-per-million turbidity, the unit is rated at 15 gallons per minute of sterilized and clarified water, with 2000 gallons to be pumped without backwashing the filter.

Nickel Alloy

THE INTERNATIONAL NICKEL COMPANY

A high-nickel alloy designed for high strength, fabrication in automatic screw machinery and for resistance to corrosion, has been announced by The International Nickel Company, 67 Wall Street, New York City. Designated KR Monel, it can be heat-treated after fabrication to provide an extra measure of strength and hardness.

The product is non-magnetic. It derives its machining qualities from thermal treatment at the mill. K RMonel is available only in rod and wire forms.

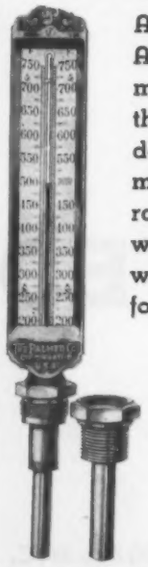
Mixer

EASTERN ENGINEERING COMPANY

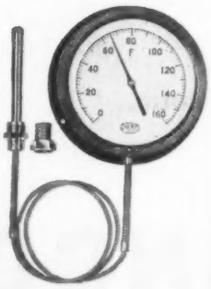
An air-powered mixer, designed for portable use in 50-and 100-gallon containers, has been announced by Eastern Engineering Company, 45 Fox Street, New Haven, Connecticut.

The unit is described as explosion-proof, and possessing a completely en-

ESSENTIAL *To National Defense . . . Are* **FINE TEMPERATURE INSTRUMENTS**



As important as proper food for the ARMY are good Temperature Instruments that help to build and maintain the equipment necessary in modern defense work . . . And PALMER Thermometers will stand the tests for accuracy because they have been made with A-1 materials, by highly skilled workmen and are thoroughly annealed for lasting accuracy.



(Write for new editions: No. 200-F and No. 300-D Catalogs)

See detailed data, page 261, 1940 Refinery Catalog

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Where temperatures go up to 1000° F and corrosion is not a factor, excellent results are being achieved through the use of Carbon-Molybdenum (0.50% Mo) steel. This steel retains its strength at the operating temperature and, in pipes, is well able to withstand the Bourdon effect.

It is comparatively inexpensive, in the light of what it accomplishes in reducing maintenance and replacement costs and insuring uninterrupted service.

Our book, "Molybdenum in Steel," which is sent free on request, contains complete technical data on this steel and others which are coming into widespread use in refinery operation.

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AND PRODUCERS

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First, you will note how vigorous, fast-working Oakite cleaning action thoroughly removes sludge and hydro-carbon deposits. As a result, heat transfer efficiency is restored and output increased. Equally important, method requires no dismantling of equipment, so you save time and money. Simply circulate recommended Oakite solution... that's all!

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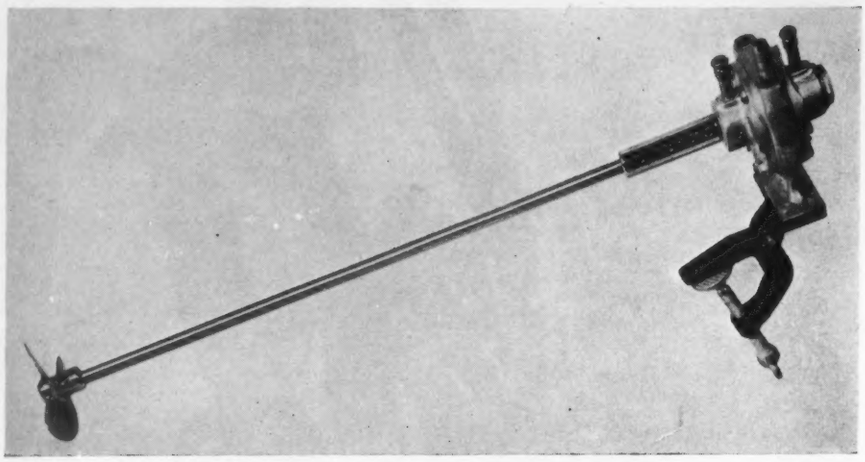


Eastern Engineering Company's Type A-1 Air Mixer

closed air motor with a wide adjustment in speed. The motor is ¼-horsepower, ball bearing, with maximum speed of 2000 revolutions per minute on 100 pounds pressure. The speed may be lowered by reducing the air pressure. The motor is equipped with exhaust silencer.

An adjustable clamp is provided for attachment of the mixer to the edge of the container. A stainless steel shaft is coupled to the motor through a nickel-plated tube-type coupling. A 4-inch diameter nickel-plated bronze propeller is fastened to the end of the shaft.

Oil Burner

JOHN ZINK COMPANY

A mechanical oil burner, utilizing both primary and secondary air and requiring no special tile for installation, has been announced by John Zink Company, Tulsa.

In operation, primary air is drawn in through the center structural tube. Flow is controlled by an adjustable damper, the design providing a diffuser action to maintain ignition of the fuel at all ratings. Primary air flow cools the burner parts. Secondary air flows between a louver-type damper door and the wall thimble. The quantity of air is regulated by moving the damper door, and louvers on the damper door spin the secondary air to create turbulent flow.

Oil is atomized by delivering it under pressure ranging from 100 to 250 pounds to the atomizer head. Tangentail slots in the passage to the discharge orifice spin the oil at a high velocity. A hollow cone of easily ignited oil mist is formed as the oil discharges. To further provide air-fuel mixture, the atomizer head is set so that the burning cone of oil mist almost fills the opening into the furnace.

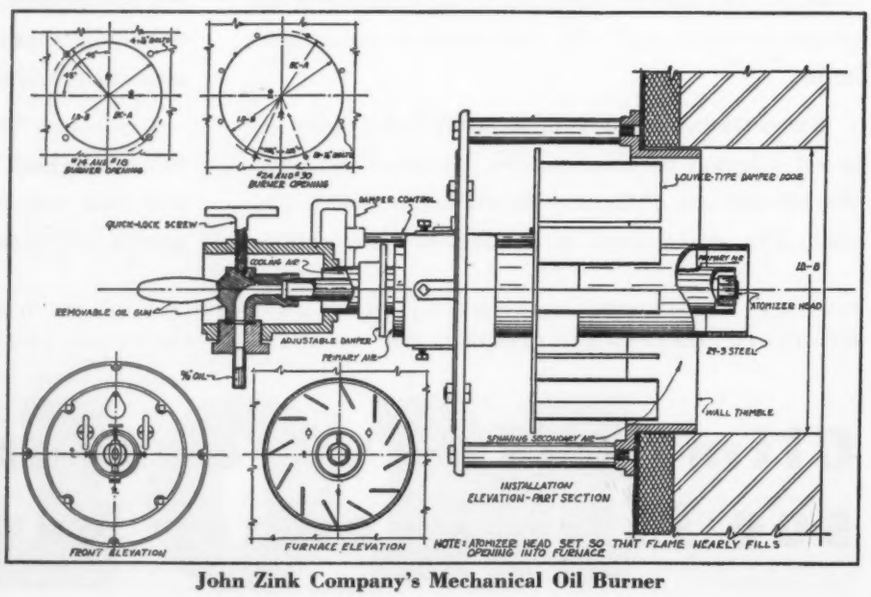
The installation is made in round, sharp-edged openings turned in the furnace wall. Where gas fuel is to be used occasionally, separate gas guns are provided, to be inserted in place of the oil guns.

Pressure Control

PICKERING PRODUCTS CORPORATION

A control unit rated to open and close the circuit of a 1-horsepower motor at 110-volt AC, to a 2-horsepower motor at 220-volt AC and to a ½-horsepower motor on 110- or 220-volt DC has been announced by Pickering Products Corporation, 8616 Grinnell Avenue, Detroit.

The device opens on increase in pressure, closes on decrease at points determined by a differential of 15 to 30



John Zink Company's Mechanical Oil Burner

KELLOGG Coordinates Research and Operating Experience into Efficient Processing Units

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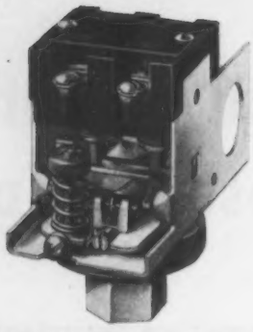
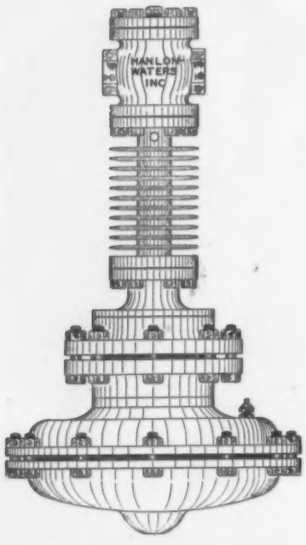


Pickering Pressure Control

pounds. Pressure range is 75 pounds. Suggested for use on motor-actuated water systems and other low-pressure pumping equipment, Model D-1 is a single-pole assembly and Model D is a double-pole assembly.

The Control employs a drip-proof cover, a pipe or motor mounting, heavy-duty laminated silver contacts and thumb-screw adjustment.

HANLON-WATERS Type 97RF
REBOILER REGULATOR



★ **Stabilizes temperature control on reboilers by maintaining the correct steam pressure for heat load.**

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★ **Eliminates friction since it is constructed WITHOUT a stuffing box.**

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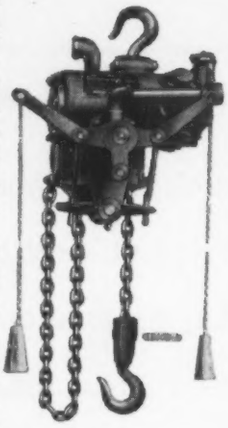
Hoist

INGERSOLL-RAND COMPANY

A flexible, welded, link-chain air hoist, designated Air-Bloc, has been announced by Ingersoll-Rand Company, 11 Broadway, New York. It is available in three sizes identified as LC-3, LC-5 and LC-7, designed to handle loads of 300, 500 and 700 pounds, respectively.



Ingersoll-Rand's Air-Bloc Hoist

Weighing less than 75 pounds, it may be moved from one job to another. An automatic up- and down-stop control is designed to prevent damage to the hoist from over-run of chain in either direction, while another feature is to prevent the load from dropping if the air supply fails.

The unit employs a 4-cylinder radial-type air motor with sensitive throttle control to permit accurate spotting of the load.

Program Clocks

ZENITH ELECTRIC COMPANY

Two new synchronous program clocks for operating time signals have been announced by Zenith Electric Company, 845 South Wabash Avenue, Chicago. Type P-512 will operate a signal at any 5-minute period, while Type PD-124 will operate a signal at any 1-minute period.

Zenith Synchronous Program Clock

The clocks have a large 24-hour dial and a 1-hour dial cam. Pointers, connected to a contact arm, ride the dials and permit the contact arm to fall only when preset time is reached.

The units are operated by heavy-duty synchronous motors. Contact can be so arranged as to operate a signal either in one ring or a coded ring, or for a definite duration of time, from 2 to 6 seconds. Units are enclosed in dust-proof case. They may be built to operate for many different purposes, such as timing industrial processes, signaling the start and end of operating periods, or daily siren testing.

Wedge Gate Valves

CRANE COMPANY

A complete line of standard iron body wedge gate valves for 125 pounds steam, 200 pounds cold working pressures, has been announced by Crane Company, 836 South Michigan Avenue, Chicago.

The line includes brass-trimmed and the all-iron patterns, with O. S. & Y. or non-rising stem, in sizes 2- to 12-inch. Also included are quick-opening and the Underwriters' patterns, alloy trimmed, alloy cast iron valves for process work, and the standard iron body valves for marine cargo oil systems.

Design features include redistribution of body and bonnet materials to elimi-

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A practical guide dealing with the use and adaptation of naphthenics and their derivatives in the manufacture of lubricating and processing products.

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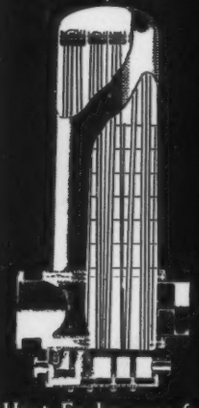

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Fracto Control

Patented in the United States and Foreign Countries.

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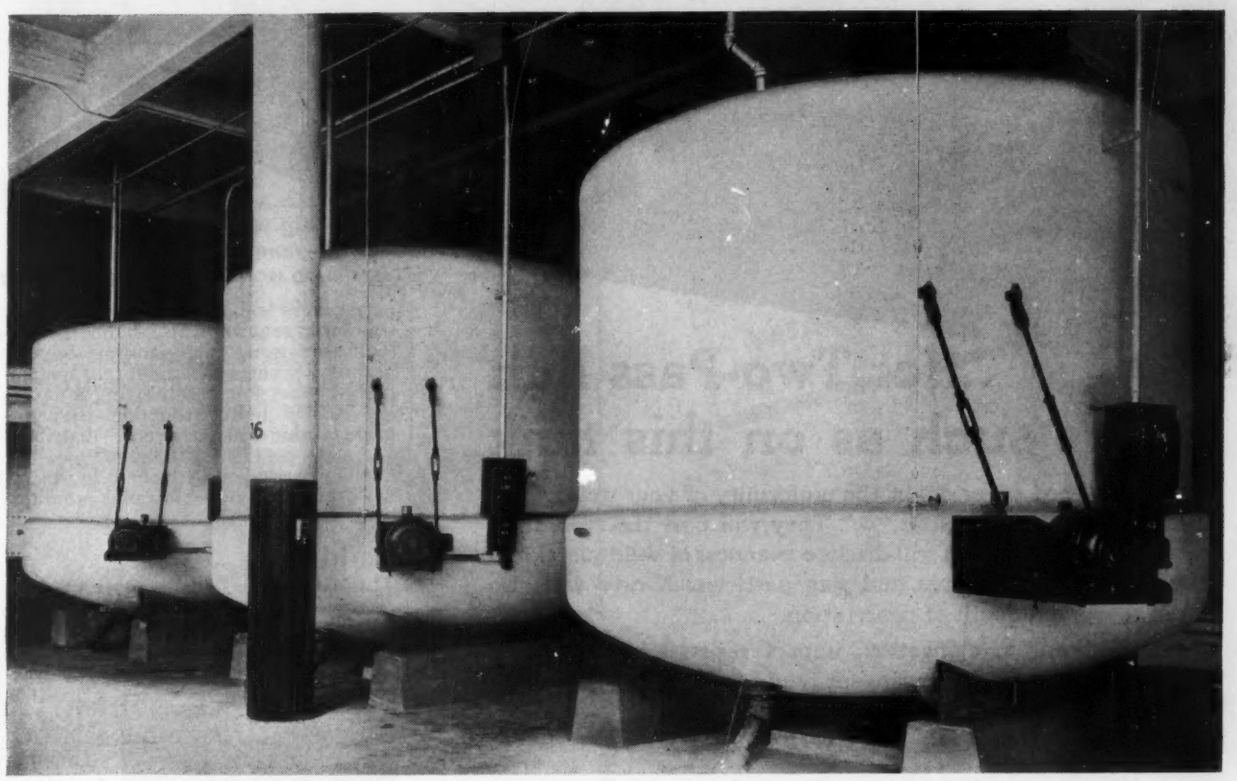
K&M INSULATION HOLDS TEMPERATURE DROP TO ONLY 19° IN 64-HOUR WEEK-END SHUTDOWN



4000-gallon sugar syrup inversion tanks in the Long Island City plant of the Pepsi-Cola Co. Tanks are insulated with Keasbey & Mattison "Featherweight" 85% Magnesia, which was supplied and installed by the Mundet Cork Co., K&M Distributor in New York City.

Five days a week the liquid sugar in these 4000-gallon inversion tanks is maintained at a high operating temperature, with a weekly fuel consumption of more than 12,000 gallons. Every Friday afternoon the plant shuts down until Monday morning. In the 64-hour interval the temperature of the liquid sugar in these tanks drops only 19°—*less than 7° per day.* That's insulating!

The credit goes to the Keasbey & Mattison "Featherweight" 85% Magnesia with which the tanks are insulated. This high-efficiency insulation saves hundreds of thousands of B.T.U.'s that otherwise would be needed each Monday morning to restore the tanks to operating temperature. Think what this means when translated into time, fuel and dollars saved!

K&M "Featherweight" 85% Magnesia is but one of a complete and specialized line of K&M insulations which are saving heat, fuel and dollars for the nation's leading industries. Keasbey & Mattison engineers, working with K&M Distributors strategically located throughout the country, can point the way to real savings in your plant, too. Write Dept. 11 for full details.

K&M "Featherweight" 85% Magnesia

"The Time-Proven Insulation"

KEASBEY & MATTISON

COMPANY, AMBLER, PENNSYLVANIA

...for Two-Pass Butt Welds such as on this tank

● You need never doubt the uniformity of your welds when you use PAGE HI-TENSILE "C." They will pass the most rigid tests. X-ray examination will disclose evenness of weld metal and absence of included gases and slag particles. X-rays will also reveal maximum depth of penetration.

Tensile strength, elongation, impact resistance and fatigue resistance meet the most stringent requirements.

Remember, too, that HI-TENSILE "C" is a 3-position welding rod—for horizontal, vertical or overhead welds.

You should have a copy of this new booklet—"Page Hi-Tensile 'C' Electrodes." It contains detailed operating instructions and briefly points out some of the advantages of this new PAGE shielded-arc electrode. Ask your PAGE Distributor for a copy —and also for information about other PAGE welding materials. Or, if more convenient, write PAGE STEEL AND WIRE, at Monessen, Pennsylvania.

PAGE ELECTRODES

PAGE STEEL AND WIRE DIVISION

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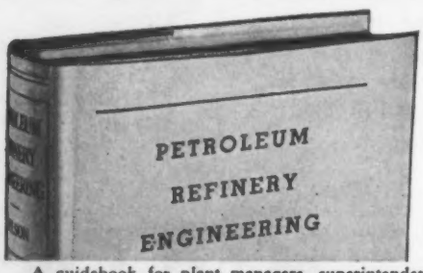
AMERICAN CHAIN & CABLE COMPANY, Inc.



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By W. L. NELSON

Consulting Petroleum and Chemical Engineer
Professor of Petroleum Refining,
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647 pages, 6 x 9, 183 illustrations
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A guidebook for plant managers, superintendents, chemists, engineers, and other refinery men. Provides a complete engineering treatment of petroleum processing, emphasizing its relation to chemical engineering. Covers fundamentals, many details of the design and operation of petroleum equipment, economical aspects, etc. Includes illustrations or examples of almost all important calculations.

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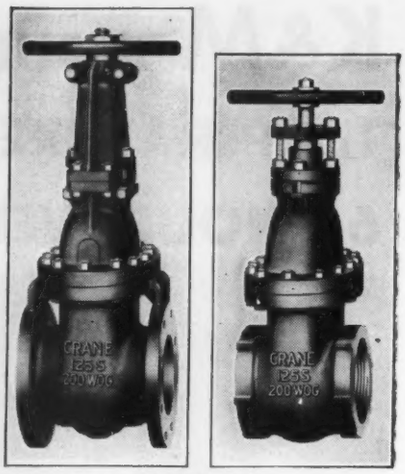


LEFT—O. S. & Y. FLANGED.
RIGHT—NON-RISING STEM, SCD.
STANDARD IRON BODY WEDGE GATE VALVES

nate excess weight and yet comply with standard requirements, handwheels of malleable iron, deep stuffing boxes to permit a generous amount of packing, body-bonnet joints employing a flat gasket closely bolted together to provide gasket compression evenly distributed, and seat rings of shoulder type to retain tight contact with the body in spite of difference in expansion characteristics.

Ladder

ALUMINUM LADDER COMPANY

A straight ladder, of aluminum and weighing one pound per foot, has been announced by Aluminum Ladder Company, 251 Adams Street, Tarentum.

Aluminum Ladder Company's Ladder

It employs aluminum alloy 61 S. T., having a tensile strength of 48,000 pounds per square inch. Side rails and ¾-inch round rungs are described as sufficiently strong to support the heaviest workman in safety. The ladder is supplied in sizes up to 16 inches wide and 20 feet long. It may be fitted with safety shoes if desired.

Multiple Cutter Turner

GISHOLT MACHINE COMPANY

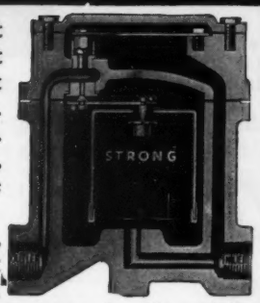
A multiple cutter turner for turret lathes, designed to make several reducing cuts simultaneously, has been announced by Gisholt Machine Company, Madison, Wisconsin.

Design features include steel construction, hardened steel rollers mounted on roller bearings, and adjustable roller arms that attach to the block. Set-up operations are facilitated by micrometer

PIPEWRENCH PETE SAYS:

BELIEVE ME... THAT FIXED 'EM!

Do something about it or else! That's about what the boss told me about those unit heaters. Nothing but cold air .... Could cure them in a day, said I, if he'd only give me Strong 70-T Traps.



Yep, he went for the tip, and those traps sure work to perfection. That special air release gadget in the top vents the air quick as greased lightning. And now we're putting Strong 70-T's on our slow kettles too.

Just ask for Catalog 63

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H 1392 West Third Street, Cleveland, Ohio

JERGUSON

GAGES

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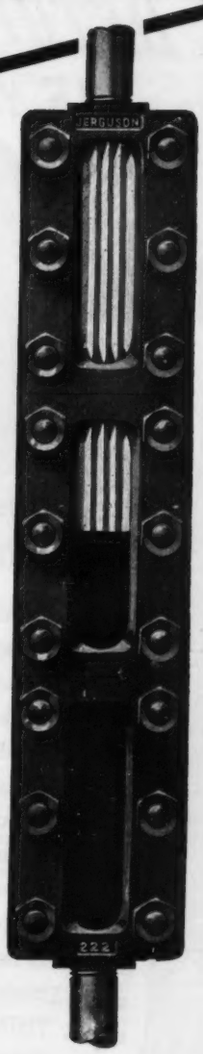

A 900-pound pressure inside an oil still is no fooling matter. Nor is the selection of the gage that is to indicate liquid levels inside that still.

In Jerguson Gages, both Reflex and Transparent, there has been no skimping in either the kind or amount of metal in the chambers for the glass. Particularly at points of stress and strain, design and cross-section give ample margin of safety.

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By A. N. SACHANEN, D. Sc.
Research & Development Division
Socony-Vacuum Oil Co., Inc.

A notable addition to the Literature on Petroleum. The three methods of catalytic polymerization (Houdry, U.O.P., and Kellogg or Unitary) are discussed at length—information that is nowhere else available in book form.

The importance of catalytic refining to the United States will be vast indeed. With attention everywhere focused on petroleum reserves, these new methods will play a vital part in furnishing a constant supply of high-octane aviation gasoline both for commercial use and for possible military needs. For this reason Dr. Sachanen's book is one of the most significant technical treatises of the day.

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Gisholt's Multiple Cutter Turner

adjustment screws on the tool blocks, and all movable parts are adjustable for wear and are enclosed to exclude chips and dirt.

The turner is available in several sizes that permit turning diameters as small as ¾-inch and as large as 4¾-inch.

Electrode

METAL & THERMIT CORPORATION

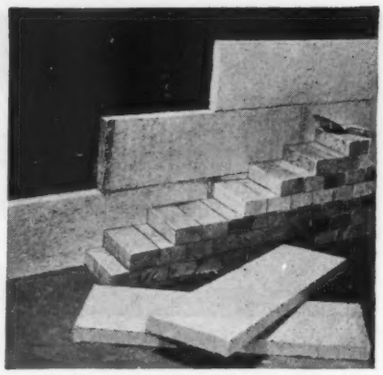
An electrode designed for manual arc welding with transformer type AC welding equipment, designated Murex Alternex, has been announced by Metal & Thermit Corporation, 120 Broadway, New York.

It is recommended for vertical-down-welding, and in the smaller sizes for welding light-gauge steel.

Insulation

JOHNS-MANVILLE

An insulating material, designated L-W Superex and rated for 1500-degree temperatures, supplied in both block and pipe-covering form, has been announced by Johns-Manville, 22 East 40 Street, New York.



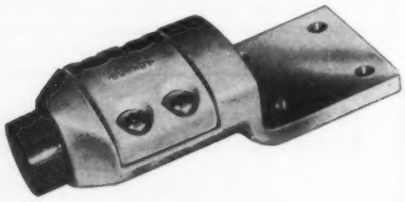
Johns-Manville L-W Superex Insulation

The insulation is of moulded diatomaceous silica type weighing 20 pounds per cubic foot. Blocks are furnished 3, 6, 9 and 12 inches wide in standard lengths of 18 and 36 inches and in thicknesses from 1 to 4 inches. Curved blocks are also available. The pipe insulation is supplied to fit standard pipe sizes in sections 3 feet long and up to 2½ inches thick. It is marked with green ends for identification.

Cable Terminal

BURNDY ENGINEERING COMPANY

A cable terminal, Type SNA-H, designed to facilitate taping of the connector and to help insure a moisture-proof seal to the insulation, has been announced by Burndy Engineering Company, 459 East 133 Street, New York.



Burndy's Cable Terminal

A recess at the cable entrance permits the end of the cable insulation to be inserted into the connector, shrouding the cut end of the insulation.

The connector is also made with hexagon head cap screws set in recesses in the cap in such a manner that they can be tightened with a socket wrench.

Drill

INGERSOLL-RAND COMPANY

Two additions to its line of "Multi-Vane" drills have been announced by Ingersoll-Rand Company, 11 Broadway, New York.

The tools range in weight from 1½ to 2⅞ pounds. Attachments are available to adapt them for light screw driving, nut running, close-quarter drilling, wire brushing and sanding. Three types of handles, straight, lever throttle and pistol-grip, are available.

Ingersoll-Rand Multi-Vane Drill

DETRICK ENGINEERING

25 YEARS OF LEADERSHIP

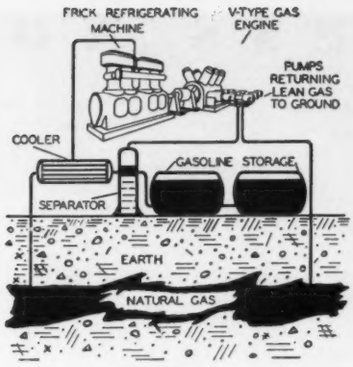
The development of the modern furnace—especially the suspended arches and walls—has been influenced in no small measure by Detrick engineering and service, during the past quarter century.

Now in response to the demand for a low-cost, standard refractory wall and arch, Detrick is again presenting an outstanding development. THINSULITE is qualified for service on all furnace walls and arches where actual abrasion is not present. It has strength, flexibility, long life, and high insulation efficiency. The heat transfer curves will surprise you. See them in the THINSULITE Catalog, sent on request.

Thinsulite WALLS and ARCHES

M. H. DETRICK COMPANY

140 S. DEARBORN ST. CHICAGO, ILLINOIS



Gasoline now made from natural gas with

Tide Water Associated-Seaboard Oil are doing it at the rate of 38,000 gallons a day in their new plant near Palestine, Texas, using the Vaughan recycling process shown in the sketch.

Two big Frick 4-cylinder compound compressors, of unique design, condense the high-octane gasoline by cooling 40 millions cubic feet of natural gas, daily, to temperatures near zero.

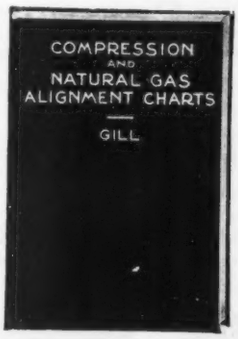
Look to Frick Engineers (they're in Branches and with Distributors all over the world) when you want dependable, profit-making equipment for air conditioning, ice-making, or any other cooling service.

FRICK CO., WAYNESBORO, PENNA.

TRADE FRICK MARK Refrigeration

COMPRESSION
AND
NATURAL GAS
ALIGNMENT CHARTS

By THOMAS T. GILL



The charts in this book have been found useful in solving field problems arising in connection with the measurement, compression and transmission of natural gas, and in the manufacture of natural or casinghead gas. As many of the formulas in common use in natural gas operations are of an impirical nature, with constants that must be evaluated under varying conditions, it will be found that alignment charts are sufficiently accurate for nearly all purposes except for metering large quantities of gas, and here they serve as an excellent check on other calculations. Contains 41 charts, 65 problems. Price $3.50 Postpaid.

Send check to the

GULF PUBLISHING COMPANY

P. O. Box 2608

HOUSTON, TEXAS

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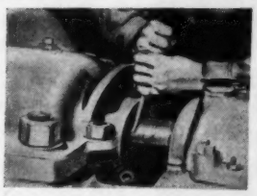

See if YOU agree with

9 out of 10

More than 90% of the engineers who have tested a working sample of Greene, Tweed Packings have become permanent users. But you need not accept even this convincing evidence of longer packing life and better service. You can test any Greene, Tweed Packings under your own operating conditions without cost to yourself.

FREE WORKING SAMPLE

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GREENE, TWEED & CO.

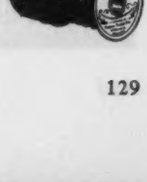
101 Park Ave. New York City

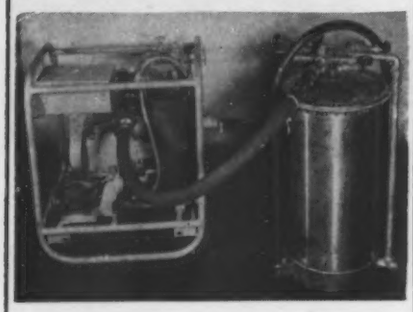
***PALMETTO**

for steam and hot fluids

* Reg. U. S. Pat. Off.

*PALCO for water
CUTNO for alkalis
*PELRO for solvents, oils
*SUPER CUTNO for acids





SAFE WATER
ON TAP
for oil field use anywhere

The Pur-O-Pumper is a low cost complete portable water purification system, gasoline driven, delivering pure, safe drinking water from any pond or stream. Used by U. S. Army, contractors, refugee camps, etc. The ideal water system for exploration crews, drilling contractors, pipe line gangs, and especially for South American oil fields where tropical water is a hazard.

Delivers 15 G.P.M.—enough to supply 500 men 20 gallons a man per day.

Technical Advice will be gladly furnished. Make your request complete so recommendation can be specific.

%PROPORTIONEERS, INC.%
Chemical Feeder Headquarters
31 Codding St. Providence, R. I.

VICTOR
Heat-Treated alloy steel
STUDS
for flanged fittings and valves

Manufacturers of
Special
BOLTS
STUDS
NUTS
of high strength, heat-treated alloy steels, corrosion and heat resistant alloys, non-ferrous metals and carbon steels for refineries, natural gasoline plants and manufacturers of refinery and oil field equipment.

Write for complete catalog!
VICTOR PRODUCTS CORP.
2641 Belmont Ave. • Chicago, Ill.

BUSINESS NOTES

Timken Announces $3,000,000 Defense Expansion Program

The Timken Roller Bearing Company, Canton, Ohio, has announced a $3,000,000 expansion program embracing its four plants at Canton, Gambrinus, Columbus, and Mt. Vernon, Ohio.

New buildings totaling 184,625 square feet will cost 572,000, with the balance to cover a 60-ton electric furnace and auxiliary equipment, machine tools and maintenance equipment. The program is being undertaken to meet defense requirements.

Key Company Offers Service On Electric Steel Castings

Key Company, East St. Louis, Illinois, has announced a service for production of electric steel castings, including designing, pattern-making, annealing and rough finishing. The company's plant is also equipped with a modern machine shop for complete finishing of either special or production runs of castings.

Offer Autographed Copies of "This Fascinating Oil Business"

"This Fascinating Oil Business," by Max Ball, which starts with the oil industry back in prehistoric days and brings it down to the most recent improvements in aviation gasoline, has now been published in a special oil-industry edition.

Autographed copies of this special edition, which sells for $3 per copy, can be purchased through the book department of The Gulf Publishing Company.

The book is an intensely interesting one, written with a charming style and covers in a non-technical manner all phases of the oil industry.

Gisholt Machine Company to Further Increase Production

Gisholt Machine Company, Madison, Wisconsin, has announced reopening of its Northern Works, in Madison, in order to meet the current demands of the defense program for turret lathes.

The expansion adds 60,000 square feet to present manufacturing facilities. It is planned that operations will start in this plant by May 1, and production will be fully under way by the middle of the year. Work has already started on reconditioning the building, last used in 1930. All necessary machinery and equipment is to be installed as soon as the building is ready.

Armstrong Changes Identification Marks on Insulating Fire Brick

The Building Materials Division of Armstrong Cork Company, Lancaster, Pennsylvania, has announced a change in brand names of its insulating fire brick, and use of different color spots at the end of each brick for identification of the various types. The following changes in names and identification have been made:

N-16, light-duty brick for use with temperatures up to 1600° F., became A-16, and is identified by a red-brown color.

N-20, light-duty brick for use with temperatures up to 2000° F., is now A-20, and identified by a blue color spot stamped on the end.

A-25, for light-duty use with temperatures up to 2500° F., remained unchanged, but an orange color spot helps identification.

For heavy-duty use with temperatures up to 2300° F., EF-23 became A-23, and is identified by a green color spot.

EF-26, for use with temperatures up to 2600° F., on the hot face, is changed to A-26 and is identified by a red color spot.

Officials said the changes were made solely for simplification purposes, with no change in the formulation or method of manufacture of any of the five brands.

"The Petroleum Industry" Presents Economic Study

A calm, straightforward, and reasonably thorough examination of present-day aspects of the petroleum industry is presented by Roland B. Schuman, head of the University of Oklahoma's Department of Business Management in his "The Petroleum Industry." The book, containing 297 pages, charts and tables, interprets the problems and the spirit of the American petroleum industry for the lay reader.

Having neither bones to pick nor irons in the fire, Schuman has reduced the industry to common-sense economic essentials. His approach is dispassionately practical and interpretative, even when he discusses the higher essentiality of lubricants over other products of the industry and suggests that effective conservation of petroleum resources is an important but no emergency problem, and might best be promoted by some form of "efficient but not panic-stricken regulation of production."

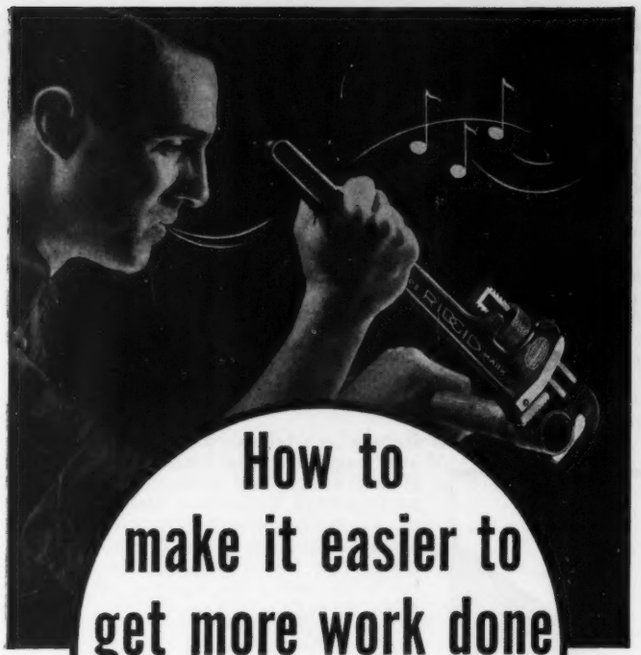
Copies may be obtained from the Book Department, The Gulf Publishing Company, Box 2608, Houston, at $3 a copy.

Supply Personals

James E. Davenport has been named vice president of engineering, development and research for American Locomotive Company, succeeding Joseph B. Ennis, who has been appointed senior vice president. Born in Charles Town, West Virginia, Davenport is a 1908 graduate of the Georgia School of Technology with a B.S. in mechanical engineering, and obtained the same de-

J. E. Davenport

J. B. Ennis



How to make it easier to get more work done in 1941

. . Easier-working RIDGID Pipe Wrenches save drudgery and time—and cut your costs!

No More Housing Repair Expense

THE country-wide demand this year is to produce *more* and *faster*. You can do your share, without extra strain on your men, by use of tools that save effort—like RIDGID Wrenches. The full-floating chrome molybdenum jaws grip without slipping, let-go without jerk. Pipe scale on hookjaw means quick-setting to pipe, adjusting nut in open housing spins easily in all sizes, 6" to 60". Comfort grip alloy I-beam handle, whole tool is balanced for effortless work. And that guaranteed housing practically ends waste of time and money making repairs. Get the work done but protect your men—buy RIDGIDs at your Supply House . . . today!

THE RIDGE TOOL CO., ELYRIA, OHIO

RIDGID

WORK-SAVING PIPE TOOLS

It's plain to see . . . why industry is rapidly changing to this outstanding thermometer. Its large, gauge-type scale with bold markings comes right out in the open in matters of accurate measurement (accuracy within 1% over entire scale). You'll appreciate this feature especially on overhead lines, or in other hard-to-get-at places; for readings will be taken in less time, with less effort, and with greater accuracy. Its all metal construction, too, can save appreciably on maintenance and renewal costs. Complete information on types, sizes, ranges, etc., is available in booklet form. Write for your copy, or request the WESTON representative in your vicinity to show you these readable, all-metal thermometers. Weston Electrical Instrument Corporation, 655 Frelinghuysen Avenue, Newark, N. J.

WESTON

FOR OVER 52 YEARS LEADERS IN ELECTRICAL MEASURING INSTRUMENTS

LABORATORY STANDARDS..PRECISION DC & AC PORTABLES..INSTRUMENT TRANSFORMERS..SENSITIVE RELAYS,.DC, AC, & THERMO SWITCH BOARD & PANEL INSTRUMENTS..SPECIALIZED TEST EQUIPMENT..LIGHT MEASUREMENT & CONTROL DEVICES..EXPOSURE METERS..AIRCRAFT INSTRUMENTS . . ELECTRIC TACHOMETERS . . DIAL THERMOMETERS.

gree in electrical engineering in 1909. He entered railway service in 1909 as a special apprentice at the West Albany shops of the New York Central Railroad, and remained with the road until 1940, when he joined American Locomotive Company to become assistant vice president of engineering.

Fred R. Davis, 64, a founder of the Audit Bureau of Circulations and advertising space buyer for General Electric Company at Schnectady, New York, for 35 years, died December 26 at his home after an illness of two years. Davis was a pioneer advocate of accurate measurement in advertising, and helped found the Audit Bureau of Circulations in 1914. He served as a director from that date until his death, and since 1927 had also been first vice president of the organization. A graduate of Worcester Polytechnic Institute with degrees of B.S. and M.S. in engineering, he entered the General Electric organization in 1901 as a test student, and in 1902 went to Fort Wayne, Indiana, as publicity manager of Fort Wayne Electric Company. In 1905, he joined the advertising department of General Electric Company in Schenectady.

Gaylord G. Thompson, former supervisor of application and control of carbide tools for Gisholt Machine Company, Madison, Wisconsin, has been appointed tool engineer for McKenna Metals Company, Latrobe, Pennsylvania. He will engineer installation and use of Kennametal hard-carbide tools and blanks in the North Central district, with headquarters in the Talcot Building, Rockford, Illinois.

GET
EXTRA
POWER
WITH WILSON EP CLEANERS

Wilson EP (Extra Power) Series Tube Cleaners were designed especially for cleaning refinery tubes and pipes in which very hard or heavy deposits of coke or scale are encountered.

Using from 25% to 40% *less air* but developing from 30% to 75% *more* power than ordinary tube cleaners of the same size, these tube cleaners clean tubes *cleaner, faster* without damage to tube walls. They reduce down-time, air and labor costs.

There is a Wilson Tube Cleaner, cutter head, or other accessory especially designed for efficiently and economically cleaning *any* refinery tube or pipe — large or small — that can be cleaned mechanically. Write for the name of our representative nearest to you or send for a copy of our new thirty-six page catalog fully describing and illustrating the complete line of Wilson tube cleaning equipment.

THOMAS C. WILSON, Inc.
PIPE AND TUBE CLEANERS EXCLUSIVELY
47-28 37th Street Long Island City, N. Y.

Robert L. Lerch has been appointed General Sales Manager of Haynes Stellite Company, unit of Union Carbide and Carbon Corporation. He has been associated with the Company since 1924. During World War I, he served in the United States Marine Corps. After the war, he returned to Lehigh University from which he was graduated in Chemical Engineering in 1922. He then spent a year and a half in various plant departments of Bethlehem Steel Company, joined the Haynes Stellite Company as a sales engineer in the New York district, later transferring to the Chicago territory, and next serving as district sales manager at Los Angeles and at Houston. Since 1929, he has been advertising manager and assistant to the general sales manager.

Fred R. Lowell, manager of oil-field engine sales for The National Supply Company for the past year, has been named manager of engine sales of the company's Superior Engine Division, with headquarters in Springfield, Ohio. A 1926 engineering graduate of the University of Wisconsin, he joined the engineering department of Fairbanks-Morse & Company. In 1928 he joined the company's engine sales staff at Chicago, and in 1933 became Philippine Islands representative in charge of sales and service of all products of Fairbanks-Morse & Company. He joined The National Supply Company in 1936, when he assumed charge of commercial engine sales in the southwest, with headquarters in Houston.

Edward A. Phoenix, assistant sales promotion manager in charge of industrial products for Johns-Manville Sales Corporation, was honored December 3 by a luncheon in New York which marked his completion of 25 years' service with the organization.

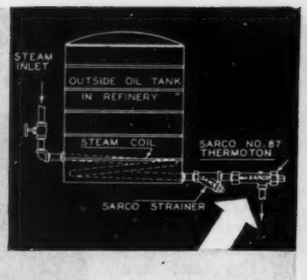
Egon Koehler, vice president of Moorlane Company, Tulsa, for the past 10 years, has resigned to join the sales department of Alco Products Division of American Locomotive Company. He is making his headquarters in Tulsa.

A. R. Engler has established a Southwestern district office in the West Building, Houston, to handle sales and service of Gisholt Machine Company and Kearney & Trecker Corporation products. He is being assisted by Starr Pitzer and Ray Dorow.

A. D. Sutherland, formerly with Lee C. Moore & Company as sales manager for its eastern territory, has joined

SARCO No. 87

The two-in-one Steam Trap



FOR REGULATION or outdoor service

Sarco No. 87 Steam Traps work satisfactorily under extremely difficult and unusual conditions. It's a non-freeze trap that works both as a trap and a temperature regulator.

It is used on extensive piping systems where condensate cannot be returned to the boiler.

For heating coils on tanks, condensers, etc., it acts as a regulator.

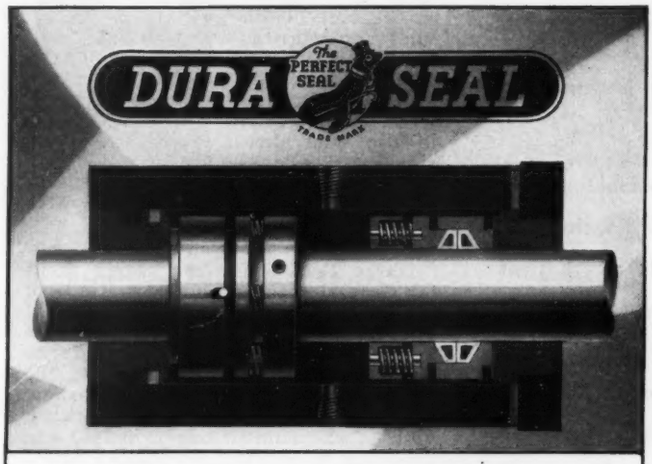
It's not expensive. It has a liquid expansion system with the famous Sarco Bellows which gives positive action and long life. It can be adjusted by the user to discharge condensate at low temperatures (but never higher than 212° when discharging to atmosphere). Catalog No. 48.

B2

SARCO COMPANY, INC.
183 Madison Avenue, New York, N. Y.
SARCO CANADA LTD., FEDERAL BLDG., TORONTO, ONT.

SARCO

SEE PHONE BOOK FOR LOCAL SARCO REPRESENTATIVE



A Mechanical Seal

That Rotates With the Shaft

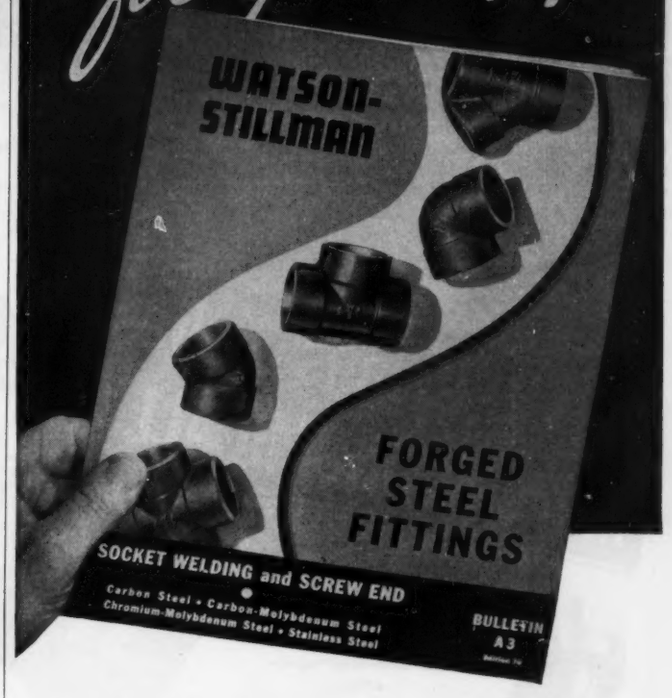
A perfected seal for centrifugal or rotary pumps and agitators working corrosive or gritty fluids. Petroleum Light Ends (Propane, Butane, etc.). Crude Oil, Chemicals and practically any condition not satisfactorily sealed by ordinary packings are now held with DURA SEAL.

Friction surfaces of DURA SEAL are reduced to about one-sixth those of conventional packings. No shaft wear . . . no sleeves needed . . . reduces fire hazard . . . power costs cut . . . fewer shut-downs.

FREE ENGINEERING COUNSEL ON YOUR PACKING PROBLEMS
Write for literature and specification sheets

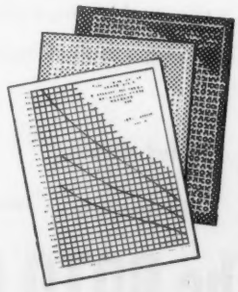
DURAMETALLIC CORPORATION
The PERFECT SEAL
KALAMAZOO MICHIGAN

Have you sent for your copy?



Specifications, dimensions and prices on the complete line of W-S Forged Steel Fittings are listed in this new bulletin • W-S Screwed Fittings of forged carbon and alloy steels in three pressure classes—2000, 3000 and 6000 pounds • W-S Socket Welding Fittings of forged carbon and carbon-molybdenum steels for use with Schedule 40, 80, 160 and double extra heavy pipe • Several pages of usable engineering data have been included. Information that you will find helpful in solving your piping problems. Write for your copy now!

THE WATSON-STILLMAN CO., ROSELLE, NEW JERSEY



PRESSURE TEMPERATURE *charts*

Use the pressure-temperature charts on Pages 21 to 25 of Bulletin A-3. You will find them most helpful in selecting the right class of fitting for your particular requirements.

WATSON-STILLMAN
Forged Steel Fittings

Chaplin-Fulton Manufacturing Company as sales engineer in marketing of pressure control equipment. Sutherland has been employed in the oil and gas industry since 1910, with the exception of one year spent overseas during World War I. Starting as a tool dresser in Oklahoma, he participated in one capacity and another during the gas boom of the Cleveland field in Ohio and the later one of the McKeesport, Pennsylvania, field. He was for a time employed as a salesman for Frick & Lindsey.

Elmer Ghrist, who has served two years in the chemical department and three years in the metallurgical department of Jessop Steel Company, Washington, Pennsylvania, has been named metallurgist. He graduated from Washington & Jefferson College in 1932.

E. E. Haubetter has been named assistant district sales manager in the Houston territory for Republic Steel Company. He has been with Republic Supply Company during the past five years, and prior to that time was with The Carter Oil Company for 10 years.

T. S. Murphy is in charge of a recently opened New York office for Black, Sivalls & Bryson, Inc., Kansas City and Oklahoma City, at 30 Rockefeller Plaza. He has a background of several years' experience in the engineering department of the company.

A. Carl Polk, Jr., employed as drilling and producing superintendent in West Texas and Gulf Coast fields for the past six years, has been placed in charge of the Texas sales territory of the Billings & Spencer Company, Hartford, Connecticut. Polk, who attended the petroleum engineering school of the University of Oklahoma, is making his headquarters at 1925 Richmond Avenue, Houston.

Jas. Emmett, Jr., has been appointed assistant sales mannager of Jas. P. Marsh Corporation, Chicago, while O. William Hage has been appointed manager of the company's gauge division, and E. C. Kluger has been appointed manager of the heating division.

Max E. Landry, Tulsa, has been named sales representative for The Bruce-Macbeth Engine Company, Cleveland, and will cover Oklahoma, northwestern Arkansas and southern Kansas.

T. J. Costello, formerly with Parkersburg Rig & Reel Company at Houston, has joined Maloney Tank Manufacturing Company as general Tulsa sales representative, J. S. Warren, company president, announced last week. He had been in the sales division of Parkersburg Rig & Reel Company for the past 15 years.

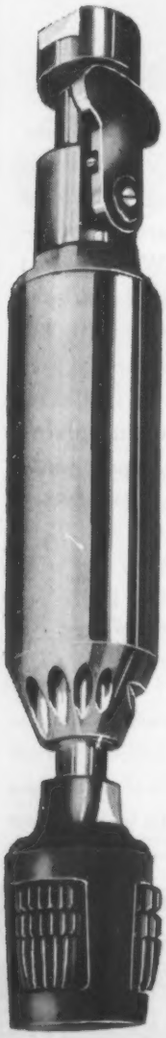
Harry L. Erlicher, purchasing agent for General Electric Company, has been named a vice president of the company. He started with the company 40 years ago, at the age of 14, as a messenger boy. He asked to be assigned to the purchasing department, and after a short time as office boy, was made a clerk. In 1910 he was named a buyer, in 1923 was promoted to assistant purchasing agent, and in 1931 was named general purchasing agent. He will continue his purchasing duties.

A. R. Weis, president and general manager of Pacific Pump Works, Los Angeles, has been elected to the board of directors of Dresser Manufacturing Company, Bradford, Pennsylvania. He became president of Pacific Pump Works in October, 1940, after serving as vice president and chief engineer of the company's organization in 1924.

J. Ed Byers, Jr., sales engineer for Black, Sivalls & Bryson, Inc., for the last year in Tulsa, has been transferred to the engineering department at Oklahoma City.

ROTO Cleans Tubes More ECONOMICALLY

Model 110 Roto Gun for 3" straight tubes, equipped with Roto Air Valve for one-man operation.



No refinery can make money unless it is working—shutdown time costs money.

Features offered exclusively by Roto enable you to put your equipment back on the line 30% faster than with old type cleaners. New design Roto motor gives you greater power and more effective use of air consumed. The Roto rapid-action air valve on the motor permits one-man operation of cleaner. Rugged self-feeding cage and swing-frame heads, drills and universal joints keep replacement costs down to a minimum.

Let us send you full details.

See our Adv. in SWEET'S and write

The ROTO Company

145 Sussex Ave. Newark, N. J.

Roto Guns are available for all sizes and shapes of tubes from 1/2" to 12" I. D., and for every kind of deposit.